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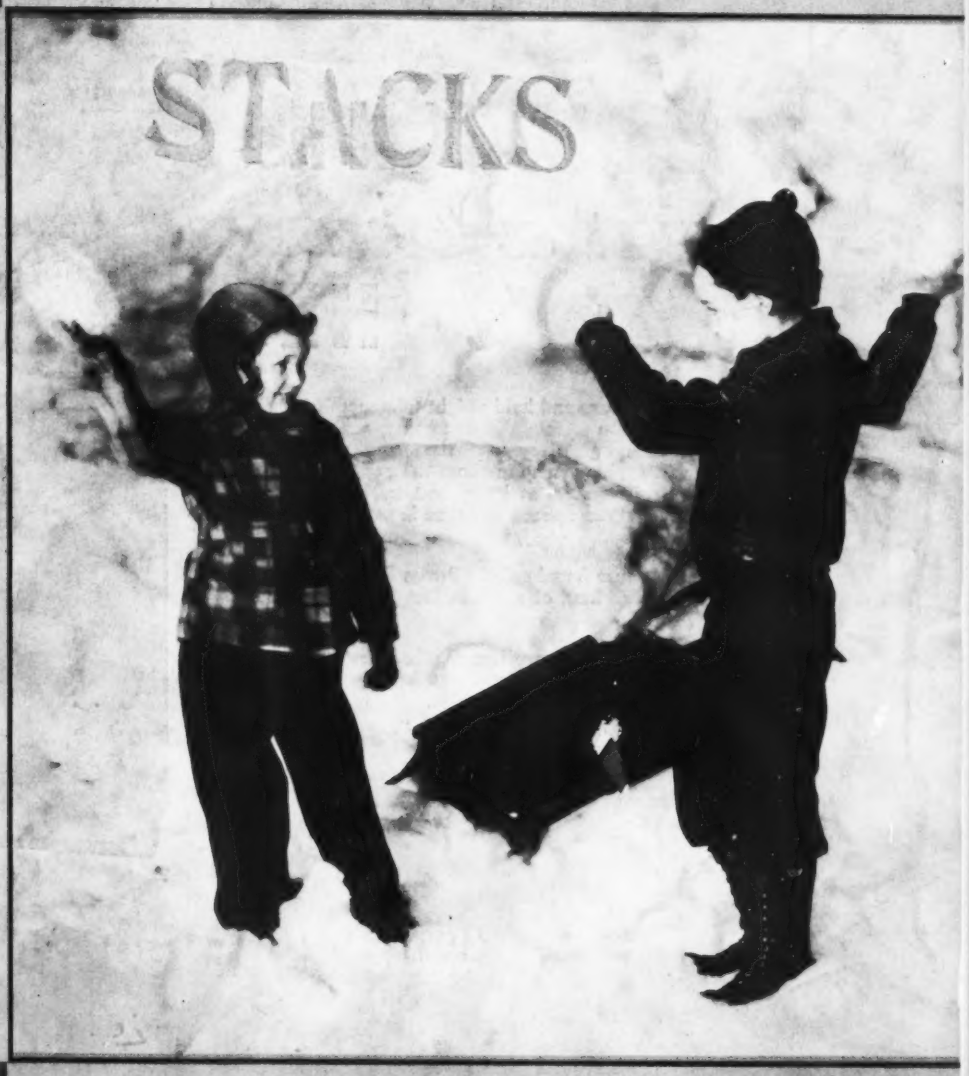
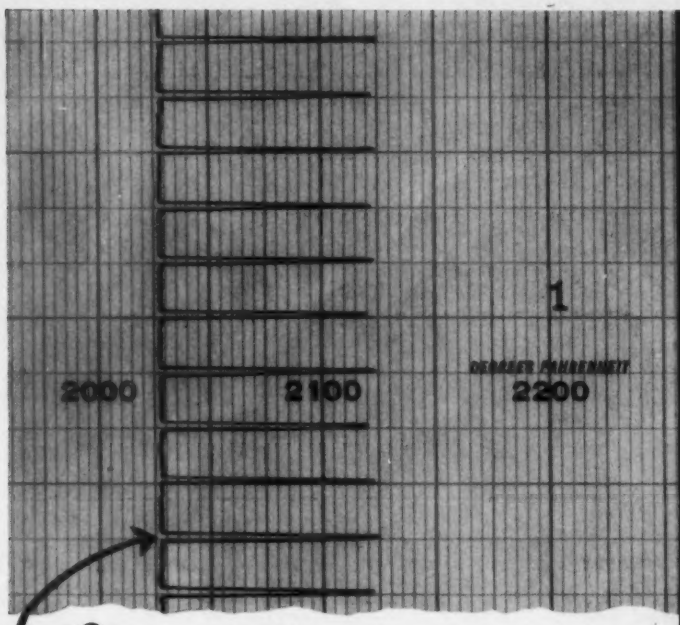
The GLASS INDUSTRY



No, it is not a snow bank, but millions of fibers of glass wool piled in front of the Newark, Ohio, factory of the Owens-Illinois Glass Co. Children of one of the company's executives happened to visit the plant and quickly discovered this "new use" for glass.

JANUARY, 1936

The Journal of Glass Manufacturing



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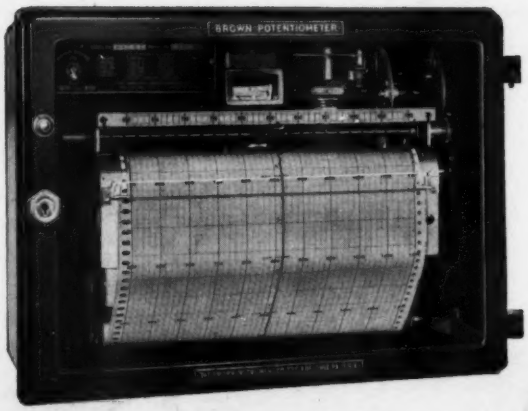

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AND
MINNEAPOLIS-HONEYWELL CONTROL SYSTEMS

To Measure and Control is to Economize

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AN IMPORTANT ANNOUNCEMENT
WILL APPEAR IN THIS SPACE
NEXT MONTH . . . . . .

watch for it!

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GLASS INDUSTRY

Devoted to Glass Technology, Engineering, Materials and Glass Factory Equipment and Operation

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Ogden-Watney Publishers, Inc., John T. Ogden, Editor.**

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THE BIG DISC

THE OUTSTANDING event of the year in the world of glassmaking was the successful completion of the big 200-inch disc at Corning. Although the whole scientific world is showering adulation upon the glassmaking industry for a technical accomplishment that is without any precedent, yet glassmen themselves seem unable to rise to great heights of enthusiasm—ultimate success was discounted in the very beginning, when Drs. Hostetter and McCauley undertook to do the job. Such is the penalty of great ability! And if it were announced tomorrow that Corning was to undertake a three or even a four hundred-inch disc every informed glassman would know beforehand that a perfect piece of glass would eventually be produced.

All scientists, glassmen or no, will thrill to the fact that there are sources of wealth still existent that will permit such men to employ their knowledge and skill to the advancement of knowledge unrelated to commercial gain.

THE NEW YEAR

WITH THE BEGINNING of a new year, we can well afford to take time from the serious business of glass making and indulge in a moment or two of day dreaming. What lies ahead in 1936?

For the plate glass industry, President H. S. Wherrett of the Pittsburgh Plate Glass Co. forecasts that plate glass will lead all the durable goods industries in increased production. He expects a better 1936 than was attained even in the boom of 1929.

Glass container sales will attempt to better the record peaks established in 1934 and (early figures indicate) again in 1935. There is no reason to expect a slacking off in 1936, as glass is gaining in popularity every year. The threat of paper and tin is not being taken too seriously.

Among the specialties, we may expect this year to see the rise of two new products—glass wool and glass building tile and blocks. It is even possible that these will eventually surpass all other glass products in total tonnage.

So, looking ahead, we cannot fail to be imbued with a spirit of optimism. The only cloud, perhaps, is the political situation—but perchance we have lived with that disease long enough to have built up within ourselves some degree of immunity.

SERIAL

N. A.

MAR 7 1939

Typical cooling system on end port furnace; L type block construction.

For L type blocks, piping under furnace.

For straight wall, piping under furnace.

For L or straight blocks, piping above furnace.

NEW K & B COOLING NOZZLES

(Patent Applied For)

Effective cooling obtained at the metal line and tuckstone area, where high velocity air streams actually reach the blocks on 5" centers. General cooling below the metal line also provided on the same centers but at reduced volume. Note the unusual visibility—all piping is behind the buckstays and may be quickly removed, as flanged connections are standard construction.

Without obligation on your part, a Kirk & Blum engineer will analyze your cooling problem and estimate the savings that K & B modern cooling equipment will effect for you. Write

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ON A SINGLE DAY there were 17 Hartford-Empire service men in the field . . . from one to seven in each of these glassware-producing states . . . These men are highly skilled in the particular phase of automatic production to which they are assigned. . . . They represent a direct personal link between our entire engineering organization and facilities and the operating requirements of our licensees.

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THE GLASS INDUSTRY
VOLUME 17, NUMBER 1, JANUARY, 1936

IMPROVEMENTS MADE AND DESIRED FOR GLASSHOUSE REFRACTORIES

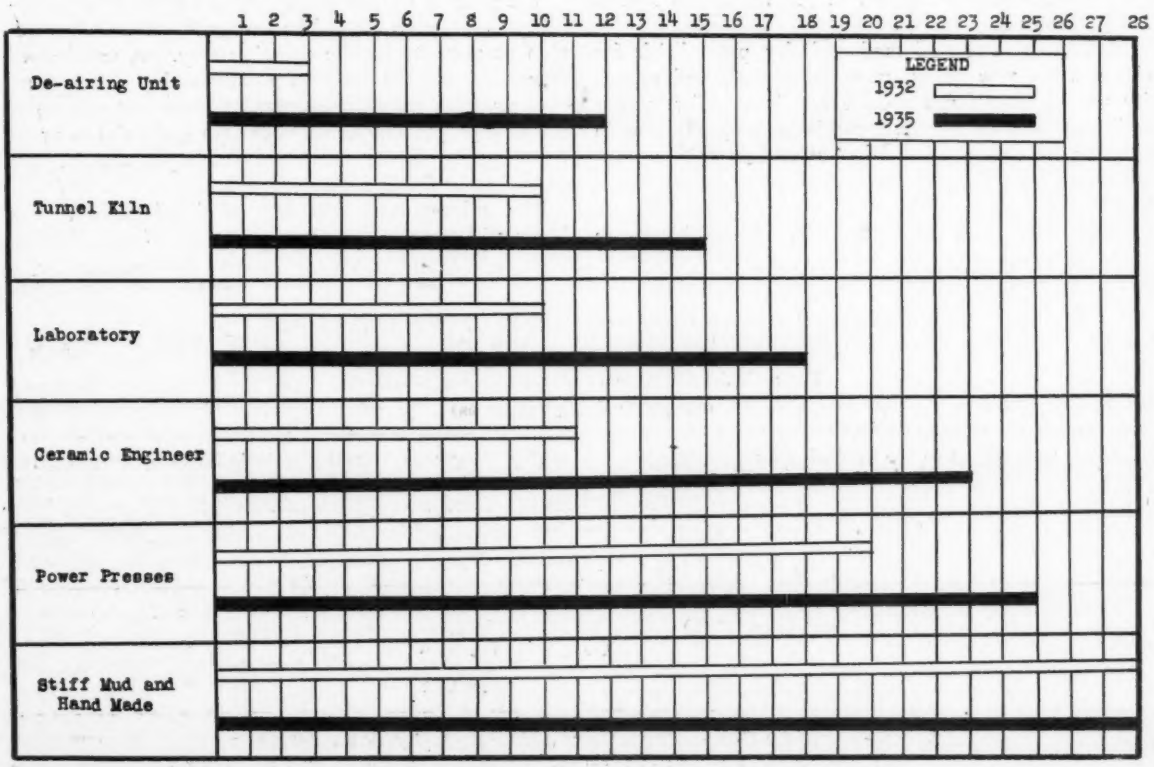
By W. L. FABIANIC
Owens-Illinois Glass Company

THE following discussion[1] aims at the progress made, and future of glasshouse refractories from the viewpoint of the glass bottle manufacturer, rather than from a diversity of fields and may add something of value and interest to the general and all-absorbing picture of refractory manufacture and usage.

The tremendous progress made by manufacturers of glasshouse refractories during the past few years is indeed worthy of comment. The majority of such refractory plants now accept and are familiar with the principles of de-airing, higher forming pressures, scientific and selective grain sizing, special grog preparation, new and novel slip casting methods, use of magnetic induction pulleys for eliminating iron minerals, the desirability of securing a definite mineralogical content by proper burning, the use of mullite forming agents and many other items of recognized merit not clearly understood or accepted a few years ago.

Several factors are responsible for this universal broadening out and acceptance of new principles, one of which is the more general use of graduate ceramic engineers both by producer and consumer. Other contributing factors are the correspondingly rapid advance in technical knowledge, improved scientific apparatus and intelligent research work coupled with the growing spirit of co-operation between producer and consumer.

During the past few years the conquering of certain difficulties in the mining, refining and calcination of certain raw materials has made available for actual use in commercial quantities many sources of supply for materials previously known to be good glasshouse refractory materials but hitherto little used because of the


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28
LEGEND
1932
1935
De-airing Unit
Tunnel Kiln
Laboratory
Ceramic Engineer
Power Presses
Stiff Mud and Hand Made

Progress in modernization made by 28 refractory plants.

extreme difficulty in producing large amounts at reasonable cost. New forming machinery, new manufacturing principles and automatic control methods have made possible many products of a uniformity and quality superior to any ever before produced. It is with pardonable pride that the glass industry can feel at least partly responsible for the remarkable progress made by some refractories manufacturers in improving and developing glasshouse refractories.

During the past year 28 different refractory plants were inspected, all concerned to a major extent with the manufacture of some phase of glasshouse refractories. The visit was in most part a revelation. The old type refractory plant with round downdraft kilns and most of the business centering in a crowded and dusty "superintendent's office" had nearly disappeared. In its place was a neat office building with courteous and efficient clerks, a small but complete control laboratory, modern tunnel kilns, neat, barrow runways, weatherproof storage sheds, an efficient pyrometer room with up-to-date temperature recorders and a much improved type of car loading platform plus, in most cases, proper facilities for handling motor truck orders.

For general interest purposes a comparison of the relative standing of the 28 plants visited, as they are equipped now and as they were equipped three years ago has been made. The chart (see page 5) depicts the advance made in three years' time by the 28 plants relative to some of the more commonly accepted modern units and methods.

RECENT IMPROVEMENTS

A glance at some of the recent actual improvements made in refractories for use in glass furnaces reveals the following high points.

Both a de-aired stiff mud and dry press brick for checkers are now being successfully made and offered for use in glass furnace checkers. They offer greater resistance to slag penetration without any sacrifice in spalling resistance. Somewhat related to this are the large de-aired refractory blocks of finer grain size which have filled a particular need in glass furnaces, for use on bridgewalls and overhang block. These block are not such a ready source of stones and slacks as the old coarse-grained porous material generally used in these locations.

A super-refractory brick made by a special burning process and composition to secure a definitely wanted mineralogical composition and offering exceptional slag and spall resistance along with high strength has now been perfected. It is finding a wide application, being peculiarly well adapted for port work.

A new and extremely refactory mix which is fabricated to withstand spalling and alkali vapors is now finding favor in use as mantle block and similar localities.

Another important development is the successful introduction of a power pressed plug of special material for use in controlling glass flow. This new plug combines great tensile strength with exceptional spalling and slag resistance and is far superior to the old type hand-molded plug with its voids and laminations.

Special burner block of many and varied characteristics are now available for use with almost any special refractories which have to be used in the port walls.

Both a greatly improved silica brick and silica mortar have appeared and found favor.

Special patching cements for use in direct contact with molten glass have been successfully developed recently and have filled a long felt need. They are definitely superior to the usual line of such materials previously on the market.

IMPROVEMENTS DESIRED

The other side of the picture shows a large list of glasshouse refractories, with which the consumer is still very much dissatisfied.

The need of a much better trough for use with revolving pots is keenly felt. The best grade of trough available at present is quite unsatisfactory. A satisfactory trough should be able to resist sudden temperature changes, have a high modulus of rupture and still be of low enough porosity and fine enough grain size to avoid throwing stones, as well as resist rapid erosion and corrosion by flowing glass.

The all-important question of hand molded flux block still remains a major one on the dissatisfied list.

QUALITY STANDARDS FOR REFRACTORY MATERIALS

(Not yet final) — **DIN Scheme 1 E. 1090.**

Tank blocks for general manufacturing processes.

(Hand moulding processes)

Quality, with regard to the kind of glass manufactured and melting furnace used.	Chemical Analysis (See DIN 1062) Al_2O_3 %	Fe_2O_3 Max. %	Seger Cone M.P. (DIN 1063) Min. %	Total Pore Space (DIN 1065) Max. %	Vol. Stability (DIN 1066) 4 hours heating T°C.	Lg. Change Max. %	Cold crushing Strength. (DIN 1067) Min. Kg./cm.²
The alumina content of the block varies for the purpose employed and the glass composition.	(1)	2.5 (2)	28 increasing with the Al_2O_3 content	29	1400	± 1.5	120

(1) The existing state of knowledge does not permit a definite alumina content to be given. On a delivery of agreed alumina content a variation of ± 2% is allowed.

(2) A variation of ± .5 per cent is allowed on the iron oxide content, uniform distribution being important. Lower values for glass with a particular desire for purity of color.

SUMMARY OF VARIOUS SPECIFICATIONS FOR TANK BLOCKS FOR GLASS FURNACES

	BUDNIKOFF	JAESCHKE	REES	ROSS
Composition	Al_2O_3 not less than 35% SiO_2 to exceed 60%	Rational analysis preferred. Clay content 35%.	Suggested: Base Clay: Al_2O_3 25-32% Total fluxes: $<$4.0% Bind Clay Al_2O_3 36-40% Total fluxes: $<$4.5%	
Grog Proportion			Flux line blocks 37.5% Side wall blocks 45% Bottom blocks 37.5%	
Size	Not greater than 1.5 mm.		Flux line blocks: 1/32"-⅛" (.75-3 mm.) Side wall blocks: 1/32"-1/16" (.75-6 mm.) Bottom blocks: 1/32"-⅛" (.75-6 mm.)	
Firing Temperature		Such that 60% theoretically possible mullite is formed.	Flux line blocks: Cone 14 = 1410°C. Side wall blocks: Cone 12 = 1350°C. Bottom blocks: Cone 10 = 1300°C.	
Refractoriness	Cones cut from block shall not melt below SK 30	Cones cut from block shall not melt below SK 30. Incipient softening under 2 Kg./sq. cm. load shall not take place below 1300°C.	Cones cut from blocks shall not be more fusible than SK 30.	Cones made from ground sample must have softening point not less than Cone 29.
Porosity: Flux Line Block Side Wall Block Bottom Block	 Not exceeding 26% Not exceeding 28% Not exceeding 32%	 Not exceeding 25% Not exceeding 30%	 Not exceeding 18% Not exceeding 25% Not exceeding 30%	Not exceeding 25%. Porosity of 2.5" cubes must not exceed 22% or less than 12% after reheating to 1400°C. for 1.5 hrs.
After Contraction 4 Hrs. 1410° (SK. 14) 2 Hrs. 1410°	Not exceeding .5%	Not exceeding .5%	Not exceeding ± 2%	Volume change shall not exceed 6%, nor be more than 1% expansion after 1.5 hrs. at 1400°C.
Compression Test (Cold) Side Blocks Bottom Blocks	 125 kg./sq. cm. 110 kg./sq. cm.	 130 kg./sq. cm.	 1600 lbs./sq. in. 112.5 kg./sq. cm.	
*Spalling Test	16 quenchings without showing any signs of destruction.	15 quenchings without showing any signs of destruction.		
Tolerance in Dimensions	±2%	±2%		
Min. Value of App. Density	1.85	1.9		
Texture	Uniform texture showing no iron stains. Colors should be light yellow to light brown. Blocks should be burnt uniformly to the core.		No patches of ironstone or other segregations, minimum "core" due to burning, regular texture free from holes and flaws.	
Corrosion Resistance				Crucibles made of raw flux block mixture and fired with flux blocks (or to 1350° in test furnace in 6 hours and held at that temp. for 1.5 hours) and subjected to a 3 day fluxing test at the temp. and with the glass (cullet) for which the blocks are to be used shall show little attack.

* Spalling Test. Specimen 25 x 12.5 x 12.5 cm. in size is heated to 850° and immersed to depth of 10 cm. in flowing cold water.

Great improvements have been made and the block of today are superior to those of yesterday, but they are still unsatisfactory. At present they appear unable to fill the requirements of both melter and refiner. Pitting and corroding to a spongelike surface with consequent throwing of stones is more marked now in the refiner than formerly. Most block, wearing evenly in the refiner, prove unrefractory enough for melter service and burn out quickly along the slag line near the doghouse end of the furnace. Much research is now being done on this particular problem and there is great hope of a speedy solution.

There has been some improvement recently in feeder forehearth refractories but there still needs to be much greater improvement if slacks and cordy glass are to be eliminated. Some new materials recently put on the market show promise but no definite practical conclusion can as yet be drawn.

Skimmer block material is improving rapidly but is still unsatisfactory to the bottle manufacturer.

SPECIFICATIONS

Specification control of glasshouse refractories thus far has not been much of a success, due to the diversity of conditions and the impossibility of getting one standard test to meet all these conditions. Tentative specifications covering all glasshouse refractories are in existence but have not been of any great assistance to the bottle manufacturer. However, the glass manufacturer would be aided greatly if the refractory manufacturer

would concentrate on and secure a satisfactory slag test for flux block. A correct and dependable specification on this one item would be of untold benefit.

It appears logical to suppose that the best indication of slag resistance of flux block is by a good dependable slag test, rather than by trying to record its probable behavior along the line of specifications for P. C. E., grog content, expansion, chemical analysis, porosity and the many other items that necessarily go into a general specification. Present-day specifications stress these points strongly and the slag test is either left out or merely mentioned. This is, of course, due to the very great difficulty encountered thus far in working out a suitable and accepted slag test and to date, in spite of all the splendid work done on slag test development, no really suitable slag test has been agreed upon.

Many tests have already been developed, both here and abroad which appeared satisfactory in the laboratory but which were not confirmed in practice. Other tests have now been developed to a point where reasonable correlation is found between test and practical results. The work done by Partridge and Bowmaker on a corrosion test of tank block is excellent and should be more widely used than at present. This test was run on several brands of block and results were secured which checked fairly close to the practical results. One objection to it was that it did not give any indication of how the metal line attack would proceed on a block actually in operation.

The apparatus developed by A. Eric J. Vickers and R. A. Bell, described in the Journal of the Society of Glass Technology, Vol. XIX, No. 74, June 1935, Pg. 151, would appear to be worthy of note altho no first hand experience has been had with it.

Because of the extreme importance in which glass bottle manufacturers hold a quick and dependable slag test for flux block, space is being taken here to reprint again the present major existing proposed specifications on flux block. The first chart was published in Keramische-Rundschau, 1933, 41, 653 and in Tonindustrie-Zeitung, 1933, 57, 1173 and the second appeared in the J. S. G. T., Vol. XVII, No. 66, June 1933, Pg. 232.

Some of the points stressed in these specifications are rather unimportant today. Perhaps other measuring sticks such as mineralogical composition should be more emphasized and the proportion of grog size needs more general agreement.

The majority of tests run on superstructure refractories fail to take into consideration the effect of alkali vapors and dust. This should be given more attention.

Many individual plants have developed specifications to suit their own individual needs, but a generally accepted standard set of specifications is the real answer to the present chaos. A word of caution is also given to individual plants developing specifications, as often their requirements demand that which is outside the scope of the refractories manufacturer to produce.

The improvement and development of glasshouse refractories naturally require research work and more expensive materials and methods. This increased cost must necessarily be borne by somebody and it is only fair that the consumer share his rightful portion of the burden by paying more money for these improved refractories. The progressive manufacturer of refractories has already found out that as long as he can supply a really superior grade refractory to the glasshouse consumer, no quibbling over prices results. A small increase in ultimate tonnage melted far outweighs any initial increase in refractory cost.

This is further borne out by the fact that more and more consumers are employing ceramic engineers merely for the purpose of checking on all new materials to insure against bad refractories initially getting into their furnaces. Such engineers are also gathering a large mass of correct and useful information relative to their employers' particular needs and problems, which are passed on to the refractories maker and which are a major aid to him in improving particularly weak points in future refractories made for specific consumers.

The consumer now realizes that new and superior grades of refractories are necessary if he is to continue his high pressure production methods with consequent heavy loads and higher temperatures and that the manufacturer of suitable refractories for such service will necessarily cost more than formerly. He is prepared, within reason, to pay this increment, which should give the refractory manufacturer all the incentive in the world to continue on such development work.

There are two warnings which must be given in conjunction with the present discussion. Many commercial glass plants, particularly the smaller ones, are feverishly conducting tests and setting up specification requirements without proper supervision and interpretation. Such work can sometimes be very misleading and become a hindrance rather than a help. It is very easy for anyone to set several brick up in a furnace for a slag test and entirely forget that perhaps the materials they are in contact with may seriously influence the ultimate results.

From a producer's standpoint some warning is also necessary. A considerable number of small plants have enthusiastically gone ahead and installed special equipmant for manufacturing certain glasshouse refractories and then come to grief because they had no fundamental knowledge of the requirements necessary for various glasshouse refractories.

Progress is needed, specifications are desired and will be secured, but carefully thought out progress balanced by correct and proper technical and practical supervision must be given. Enthusiasm without proper knowledge and a cautious feeling of the way cannot make suitable glasshouse refractories.

[1] The author wishes to express his thanks and appreciation to Mr. J. W. Wright for advice and suggestions in the preparation of this article.

BORAX GOES SKIING

In addition to its many uses in the glass and other industries, Borax now finds itself an A-1 bona fide substitute for snow. Saks-Fifth Avenue, New York department store, has erected a ski run on its sixth floor so that city folk may practice their herringbones and Christianas during the week in preparation for country weekends. The slide is 14 feet high, 15 feet wide and 63 feet long and you can learn everything you need to know about skiing on its borax covered surface.

A two-year course in traffic safety has been introduced in the Milwaukee public schools this Fall. The course will include a study of safety glass.

THE 200-INCH DISC IS COMPLETED

ONE year and one week from the date of its pouring, the giant 200-inch telescope mirror was removed, December 9, from its annealing oven at the Corning Glass Works. The disc was immediately approved and ordered shipped by representatives of the California Institute of Technology's observatory council, who had come to Corning to inspect it. Cleaning and sand blasting, which was then expected to occupy several weeks, has since been progressing satisfactorily, and sometime in January it is expected that this the largest disc of its kind ever cast will be on its way to California.

The history of this giant borosilicate disc really dates back to 1917, when the Mt. Wilson 100-inch disc was completed. At that time Dr. George E. Hale predicted that another generation would live to see a 200 or even a 300-inch mirror. Dr. Hale's estimate was too conservative; as early as October, 1928, the International Education Board promised the California Institute of Technology funds sufficient to make a 200-inch reflector, including the telescope, laboratory and necessary accessories, at a cost which was then estimated would be $6,000,000.

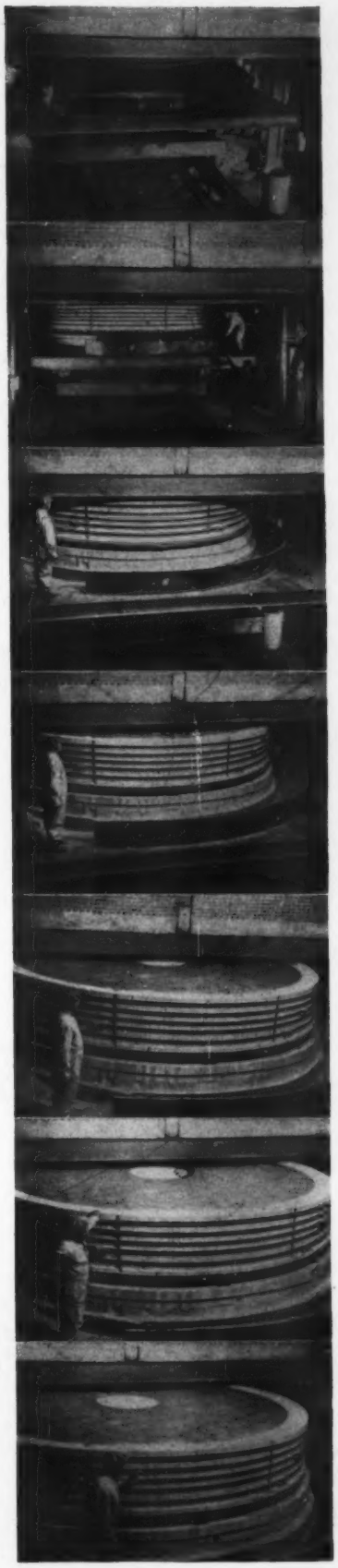
Then began a world-wide search for experienced telescope builders and optical experts capable of such an epic construction. Between 1929 and 1932, Dr. Elihu Thomson experimented with fused quartz for the mirror at the Lynn General Electric plant; but he found quartz impracticable for a mass of such tremendous size. A preliminary design and model of the telescope had meanwhile been completed and the estimated cost was revised to $12,000,000.

In March, 1934, the first 200-inch disc was cast. The glass quality was excellent and this disc could have been used but some minor accident in the mechanical construction of the mold made it seem advisable to do the work a second time. So in October of that same year, it was decided to cast another, using the experience gained to slightly alter the mold construction.

The two fundamental divisions of the problem were the pouring and the annealing. There were, of course, many side problems. These might be loosely classed as, first, the problem of determining how the substances used would act under calculated conditions; second, the problem of handling quantities of material under changing conditions; third, the problem of transporting large masses of material with minimum shock and strain.

The pouring operation started at 7:17 A. M. on Sunday, December 2, 1934, when one of the two pouring crews, which worked in relays, drew out the first ladle of molten glass. About 40 tons of glass were melted, of which about 20 tons were poured in the mold.

Following the pouring, which occupied about six hours, the temperature of the mold was raised to about 2400°F. and was kept at this temperature for about ten hours. The heat was then turned off, and the mold and its contents allowed to cool. A number of hours were



1

2

3

4

5

6

7

Action photos taken as the disc comes out of the annealer in easy stages. 1 and 2 show the disc being lowered. After being lowered to the floor below, the huge mass was moved forward on tracks, which operation begins at photo 3. More and more of it appears until at 7 it is two-thirds out of the building.

then required until the glass reached a temperature of about 1200 degrees, when the molten disc was lowered from its pouring position under the bee-hive by means of the synchronously operating jackscrews of the locomotive hoist. Actually it was caused gradually to descend from the pouring floor level, and then, on the floor below, it was moved, in its carriage on the hoist, horizontally, and on that floor level, to a position beneath the annealer. Concentrically underneath the annealer, the mold, with its contents still at dull red heat, was raised gradually into place within the annealer, and when in position, an insulating seal was affected to the degree required for the annealing process. This transfer from bee-hive to annealer occupied about one hour.

For almost a year, the temperature of the disc has gradually been lowered, sometimes at the rate of less than a degree a day. The floods in New York state last July, however, almost put an end to this gradual cooling operation and for some time there were great fears that the work would be destroyed. The floods actually did result in shutting off the heat for 48 hours, while the electrical equipment was relocated on another floor of the building. As it was, the metal roof of the annealing oven touched the top surface of the glass, causing large scars, which, fortunately, were not too deep to cause the glass real concern. The top surface of the disc will be ground out to saucer shape, of course, when the mirror is finished.

At length, on December 9, the disc was removed from the annealer. At a given signal, four giant jackscrews, operated by electric motors, began to turn the lifting and lowering mechanism on the 60-ton locomotive hoist and gradually lowered the assembly of mold and disc. Then the locomotive hoist traveled horizontally along broad gauge tracks to the testing house which is on the bank of the Chemung River which rose so dangerously during the floods last summer.

In the testing plant the disc was subsequently raised to a convenient working position and the giant mold rim taken apart. Then the body of the mold, which was built of ceramic bricks, was taken down so that the disc itself could be lifted from the base of the mold, which contained hundreds of heating elements. The disc was then hoisted to a vertical position in the testing plant and the 114 ceramic cores which form the geometric pattern on its underside were removed by sand blasting. The purpose of these cores is to make a geometric pattern of hollows in the back of the disc. These serve to lighten its weight and also simplify the problem of mounting the disc in the finished telescope.

Other surface cleaning operations followed, and when these are completed the Corning physicists will get to work with optical instruments and examine every portion of the disc's surface. They will measure its structure from the standpoint of mechanical strength and optical properties.

As glassmen know, when glass is subjected to stress mechanically its index of refraction is changed. This effect is rendered apparent by passing polarized light through the glass specimen, bringing about optical effects known as bi-refringence. By suitable apparatus the amount of the bi-refringence or the difference between the changes in index of refraction can be measured. It has been found that for a given load on a glass block there is a definite corresponding amount of bi-refringence. Consequently, if this factor between stress and bi-refringence is known, the amount of stress can be determined by the quantity of bi-refringence developed in the glass.

For optical instruments it is essential to have glass as free as possible from internal strain. If the glass is not well annealed, or free from such strain, the curvature of the optical part will not remain constant with changes of temperature or over a period of time. The effect of such a change in curvature on a large astronomical mirror would be to give an image which is not sharp. For these reasons the 200-inch disc was annealed through a carefully controlled cycle over a period of months.

Examination at the rim of the 200-inch disc has indicated a bi-refringence of 25 millimicrons per centimeter of light path. It is anticipated that as further measurements are made throughout the central portions of the disc the degree of strain will be even less than that indicated at the rim. During the war 20 millimicrons was considered to be good annealing for precision optical glass. However, this applied only to very small pieces of glass such as are used for field glasses, range-finders, and periscopes. It is believed that no large mass of glass has ever been cooled with such a small degree of residual strain. The corresponding figure for glass at the breaking point would be many times this amount.

Now that the disc has been tested and approved, shipment to California for grinding and polishing is the paramount problem. Two crates will be used for shipping purposes, the interior being supported by the exterior. The bearing surfaces are to be spaced by a vibration absorbing material, probably by blocks of a cork composition. The crates themselves will be an assembly of boiler plate, eye beams and angle iron. As an indication of the enormity of the task ahead, 15,000 inches of welding will be used to hold the crate together.

The crate for the 200-inch disc, because of the enormous size and weight, is designed with several functions in view. First of all, it was necessary to have some device by which this large mass of glass could be supported vertically while the ceramic cores were carefully removed. Accordingly, provision was made to carry the load of the disc in its crate by means of trunnions, around which the slings from the chain hoist were fastened. The second function of the crate is to insure safe transportation to the Pacific coast. Obviously the outer crate will have to be fitted with trunnions so the railroad crane can move it from a position on the ground to the well-hole car. When the disc arrives at Pasadena it will be transported flatwise in its crate on a large truck to the optical shop of the California Institute of Technology. The truck to be used in this case will be one of those gigantic automotive devices used on the Boulder Dam project for transporting the enormous iron pipes used for the sluiceways. When the disc is received in the optical shop the outer crate will be removed and the second crate will be used as a means of hoisting the disc to the grinding machine.

Once crated, the problem of shipping will have to be met. The route is still being worked out. Because of its great size, the shortest route to California cannot be used. Low bridges and narrow tunnels interfere. And once the mirror is in California and has been

properly ground and polished, and an aluminum coating put on, there will still be the difficult task of transporting it up Palomar Mountain where the observatory will be located. However, a special road is now under construction to facilitate transportation.

But when all of the difficulties have been overcome, it is expected that the 200-inch disc will prove of tremendous scientific value in the study of the universe. Neither high magnification nor resolving power is expected in the case of large reflectors. High magnifying power is not sought, but increased brightness of the star images.

Among the advanced possibilities to result from the 200-inch mirror in use is light collecting power. More light is the chief need. By reason of its area, the 200-inch will collect four times as much light as the 100-inch. Astronomers will see what may exist in regions about 1,200,000,000 light years away. The disc's much larger angular diameter (ratio F: 3.3) will greatly condense this light, and give a gain for photographic purposes equal to ten times that of the 100-inch disc. This gain will again be multiplied by the various improved auxiliary devices developed at the expense of the 200-inch fund since the inception of this project.

For example, Dr. John Strong, of the California Institute of Technology research staff, has successfully used a vacuum chamber 40 inches in diameter, with which the 36-inch Crossley Reflector mirror of the Lick Observatory, and many smaller mirrors and gratings, have been coated with aluminum by evaporization. The 100-inch reflector only recently has been re-coated. Hitherto, by aluminizing two of the smaller mirrors employed with it, the speed of this telescope has been doubled in the "violet." Assuming that the 200-inch can be coated in the same way, this factor will come into the gain.

With the new form of mounting which is now being developed the observer will do a great deal of work in the primary focus, without the losses due to secondary mirrors formerly necessary. The mounting will be rigid and massive enough to carry the observer at the upper end of the tube, in a small constant temperature chamber (constant during a given period of observation, so that the seeing may not be effected by heat from the observer's body.) In spite of the angular aperture, the focal length (55 feet approximately) will be great enough to give direct images of the moon and planets, of sufficiently large scale to make direct photography effective at this point.

As the chief obstacle in direct photography of objects showing fine detail is the rapid oscillation of the image caused by the atmosphere, the snap-shots of the moon, etc., possible at this focus, should show structure now beyond reach photographically. These brilliant images should count materially in such work as that of Wright and his associates concerning the moon; Stebbins' work on stars and faint nebulae with the photoelectric amplifier; and Hubble's work on remote spiral nebulae.

This brief sketch of Corning's great masterpiece deals but little with the actual glass itself; indeed, the narrative continually suggests problems and raises queries which glassmen would like to see answered. The GLASS INDUSTRY feels itself particularly honored at being able to announce that some of these will be discussed in an early issue by Dr. George V. McCauley, of Corning, the physicist in actual charge of the work since its inception.

The first view of the disc. The scars made by the roof of the oven are faintly discernible in the center foreground.

Drs. Hostetter and McCauley talking things over.

Dr. McCauley tells the story to the news reels.

Inspection—with no fault to find.

Tony Miller starts the work of sand blasting.

THE INFLUENCE OF COMPOSITION ON THE COLOR OF SULPHUR AMBER GLASS[1]

By K. LITZOW AND G. BROCKS

GLASSES were melted in a gas furnace under an atmosphere as nearly neutral as possible. As many as 15 small crucibles were heated at the same time in order to have the results comparable in respect to atmospheric influences. Since the tests were of a practical character, elaborate physical and chemical examinations were omitted and the colors of pieces of equal thickness were compared by eye.

First there was determined the most favorable percentage of carbon and sulphate to use in a neutral atmosphere. Charcoal was used for carbon and sodium sulphate for sulphur. The base glass was composed of

70 per cent SiO_2,
10 per cent CaO,
20 per cent Na_2O,

The different quantities of carbon and sulphate were added as percentages of this glass. The slight deviations in composition thereby introduced were negligible.

Carbon was added to the glass in quantities of 0.25, 0.5, 1, 2, 3, 6 and 12 per cent. It was found that 0.25 and 0.5 per cent carbon made no appreciable change in the glass. Apparently, this much carbon is burned out unless the furnace is strongly reducing. With 1, 2 and 3 per cent, delicate yellow to honey-colored glasses resulted; with 6 per cent carbon the glass is again rather colorless, and with 12 per cent a bubbly light gray violet melt was obtained.

These melts were repeated with additions of 1, 2 and 6 per cent sodium sulphate. The results are given in Table I.

The strength of color is dependent on the carbon-sulphate ratio. With very pure materials, a brown color without sulphate is impossible; the glass is only light yellow. The carbon must be in a definite ratio to the sulphate content. If there is not enough carbon, the color is too weak and if there is too much it also decreases.

We have seen that where no sulphate is intentionally added carbon first begins to color at 0.5 per cent. If the test is repeated in covered crucibles in a reducing atmosphere, 0.5 per cent carbon shows a distinct coloration.

Hence, if it is desired to produce a dark brown glass, the carbon and sulphate must be increased simultaneously. These results were confirmed by factory experience. By increasing the carbon alone, instead of darker glass, lighter glass was obtained.

In Table 2 are given the results obtained by increasing sulphate while the carbon was held constant. They show that, if the sulphate is appreciably higher than the carbon, the color decreases. From these results the conclusion was reached that additions of 1 per cent charcoal and 1 per cent sulphate would be best suited for further study.

If we consider the carbon as a reducing agent, then the same color must be obtained by other substances. A glass with 2 per cent sulphate was reduced with metallic zinc, silicon and aluminum in powdered form. A second test was also made with aluminum sticks. These tests showed that under suitable conditions aluminum and silicon can be used for reduction.

TABLE 2

0.0%	sulphate	2%	carbon—light yellow
0.1	sulphate	2	carbon—honey
0.2	sulphate	2	carbon—light reddish brown
0.5	sulphate	2	carbon—red brown
1.0	sulphate	2	carbon—brown
2.0	sulphate	2	carbon—dark brown
6.0	sulphate	2	carbon—dark brown
12.0	sulphate	2	carbon—red brown
24.0	sulphate	2	carbon—white

The advantage of this method is that the reducing agent does not form gas and, therefore, does not tend to produce seeds as is the case with carbon. It is interesting that aluminum sticks gave better results than the powder. Zinc, which is otherwise an especially good reducing agent, gave no color.

The carbon-sulphate mixture which was established as most suitable was added to glasses whose composition was systematically altered. We used the method of substitution employed by Gelhoff and Thomas. With a constant alkali content, the silica was replaced with various 2 and 3 valent oxides; in one case by 10 per cent and in the other by 25 per cent.

The compositions were:

Type 1	Type 2
18% Na_2O	18% Na_2O
72% SiO_2	57% SiO_2
10% RO (R_2O_3)	25% RO (R_2O_3)

The oxides introduced included MgO, CaO, SrO, BaO, ZnO, CdO and B_2O_3. Table 4 gives the results.

TABLE 1

Carbon in %	0.25	0.5	1	2	3	6	12
Without Sulphate	White	White	Delicate Yellow	Honey	Honey	White	White Bubbly
1% Sulphate	White	Light Brown	Brown	Brown	Light Brown	Light Yellow	Gray Bubbly
2% Sulphate	White	Light Brown	Brown	Brown	Dark Brown	Light Brown	Yellow
6% Sulphate	White	White	Yellow	Yellow	Dark Brown	Dark Brown	Dark Brown

TABLE 3

	0.2%	0.4%	0.5%	0.6%	0.8%	1.0%	1.5%	2.0%
Zn Powder	White	White	White	White	White			
Si Powder	White	White	Brown	White	White Bubbly	Gray Bubbly		
Al Powder	White	Light Yellow	Yellow	Yellow	Yellow	White Yellowish	Gray Bubbly	
Al Sticks	White	Yellow		Light Brown	Light Brown	Medium Brown	Yellow Bubbly	Gray

TABLE 4

	MgO	CaO	ZnO	SrO	BaO	B_2O_3	CdO
10%	Brown	Brown	Light Yellow	Brown	Brown	Light Brown	Light Brown
25%	Medium Brown	Medium Brown	White	Darker Brown	Darker Brown	Dark Brown	Lemon Yellow

The two most interesting oxides were repeated with a longer series and batches having 5, 10, 20 and 30 per cent ZnO and CdO were melted. With ZnO, the color grew lighter and disappeared at 20 per cent. With CdO, also, the brown color was suppressed and with higher quantities only cadmium sulphide red was obtained, as in Table 5.

TABLE 5

	5%	10%	20%	25%	30%
CdO	Brown	Honey	Light Lemon Yellow	Lemon Yellow	Red
ZnO	Light Brown	Light Yellow	White		White

From the melts in Table 5 it may be considered as proven beyond doubt that high ZnO and CdO contents suppress the iron sulphide color. This seems more probable, too, from the fact that in aqueous solutions zinc and cadmium sulphides are more easily precipitated than iron sulphide.

A few tests were made on the influence of the univalent oxides. Lime was held constant at 10 per cent. As SiO_2 was replaced with Na_2O, the glasses became darker with increasing Na_2O content. The same thing was true of the K_2O glasses. The K_2O glasses were always lighter than the corresponding Na_2O glasses. This observation is contradictory to that of H. Thiene[8]. However, the discrepancy can be explained in that the author cited varied his glasses in molar quantities.

[1] The results of a series of experiments conducted at the Schlesichen Glasfachschule at Bunzlau. Reported in Sprechsaal **68**, 51-53 (1935).

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Brooks Brothers, exclusive New York haberdasher, has installed a window of invisible glass adjacent to a window of ordinary plate glass. Results, in terms of increased sales, have presented quite a serious internal problem, since every department wants its goods to be displayed there.

A section of the all-glass reception room in the Owens-Illinois Glass Company's new offices at Toledo. The walls are made of glass block. The ceiling is also of glass, and made sound-proof and fire resistant by a lining of glass wool. The effect is novel and highly pleasing.

Properties of Various Alloy Metals Used in the Glass Industry

Trade Name	Approximate Composition	Recommended Types of Service	Thermal Cond. Room Temp. C.G.S. Units	Tensile Strength Hot Rolled Bars (000 omitted)	Brinell Hardness	Max. Temp. °C For Continual Operation in Air
Ascoloy 55	C 0.25; Si 0.60; Mn 1.0; Cr 28.0	High temperature, furnace parts	0.059	75-100	160-200	1175
Calite B	Cr 20.0; Ni 8.0; Fe & Al balance	Heavy loads at high temperatures	0.027	....	340	980
Calite N	Ni 65.0; Cr 18.0; Fe balance	High temp., resistance to heat shock	0.033	....	170	1095
Carpenter No. 3	C 0.30; Cr 20.0; Cu 1.0	Heat resisting parts	....	100	196	....
Delhi Hard	C 1.0; Cr 17.5	Abrasion resisting parts	....	110	220-230	....
Duraloy A	Cr 28.5; Fe balance	Furnace parts, high temperature	0.080	80-90	160-210	1150
Enduro S	C 0.08; Si 0.5; Mn 0.5; Cr 13.5	Heat resisting parts	0.097	75-160	150-340	760
Enduro A	C 0.1; Si 0.88; Mn 0.5; Cr 17.5	Heat resisting parts	0.052	70-90	166-196	870
Enduro KA2	C 0.15; Mn 0.5; Si 0.75; Cr 18.0; Ni 8.5	Heat resisting parts	....	....	....	925
Fire armor	C 0.5; Si 1.0; Mn 1.75; Cr 20.0; Ni 60.0	Furnace parts, high temperature	0.033	....	200	1095-1260
KA2-S	C 0.07; Cr 18.5; Ni 8.5	Furnace parts, high temperature	0.052	80	135	870
Midvale HR	C 0.35; Mn 0.55; Si 1.4; Cr 19.5; Ni 7.25; W 4.0	Pyrometer tubes, recuperator parts	....	85-135	....	900
Misco	C 0.5; Mn 0.7; Si 1.5; Ni 36; Cr 16.0	Furnace parts, high temperature	0.025	97	235-245	....
Nickel	Ni 99.2	Glass making equipment	0.140	70-80	105-125	650-760
Nichrome	C 0.8; Ni 60; Cr 15; Fe balance	Glassrolls, pyrometer tubes, furnace parts	0.033	....	156-187	1000
Nicral C	C 0.3; Mn 1.5; Si 1.5; Ni 26.5; Cr 11.0	Glass blowpipes, pyrometer tubes	....	....	....	815
Resistal No. 7	C 0.2; Si 1.5; Cr 25.0; Ni 17.5	High temperature, furnace parts	....	117-136	217-277	1095-1150
Stellite No. 1	C 0.50; Cr 30; W 15.5	Coating surface for resisting abrasion	....	....	512	1000
Thermalloy A	C 0.4; Mn 1.0; Si 1.0; Cr 17.0; Ni 40	Pyrometer tubes furnace parts	0.012	....	241	1095
Thermalloy C	C 0.5; Mn 0.5; Si 0.4; Cr 27.5	Resistance to S compounds	0.019	....	196	1095
VZA	C 0.09; Mn 0.5; Si 0.5; Cr 18.0; Ni 9.0	High temperature, furnace parts	....	150	200	925
Xite	Ni 38; Cr 18; Mn 1.2; Si 2.0; C 0.5	High temperature, furnace parts	0.014	....	....	1010
No. 1100 Alloy	C 0.65; Mn 0.5; Si 1.85; Cr 22; Ni 23	High temperature, furnace parts	....	....	....	1150

ANNEALING PYREX

Annealing of Pyrex Chemical Resistant Glass, By G. W. Morey. From *Ind. and Eng. Chem.*, Vol. 27, No. 8, 966-972, Aug. 1935.

The theory of glass annealing is briefly discussed as a prelude to the description of the actual method used in determining the annealing constants of Pyrex chemical resistant glass. The apparatus used was the same as that used by Adams and Williamson, slightly modified to improve the temperature distribution and the measurement of the bire fringence. The samples were first strained by heating to about 650° C and then cooled freely while protected from draft. Before the determination the samples were preheated for about half an hour at about 50°C lower than the test temperature.

Using the annealing constants found in the Adams and Williamson equation, the proper heating temperature and cooling rates for successful annealing of the usual types of Pyrex glass chemical apparatus have been derived. The use of the prescribed annealing schedule will result in a maximum stress of 20 $\pi\mu$ per Cm.

A sample of Pyrex chemical resistant glass was annealed at 430°C at which temperature it required two years for the removal of most of the strain. After an initial period of about 6 weeks the bire fringence diminished in accordance with the empirical equation derived by Adams and Williamson. This initial period of more rapid release of strain is usually present, even at temperatures at which the glass anneals rapidly but in the two year experiment it is more clearly separated from the straight line part of the annealing curve. The initial period may correspond with the time required for the glass to reach the equilibrium condition for the given temperature, a process which takes place more rapidly than does the actual annealing, while the straight line portion may correspond to the release of stress in a glass under equilibrium conditions.

An x-ray study of the glass held for two years at 430°C made by B. E. Watten of M.I.T. indicated no crystallization had taken place, but that there had been a slight increase in regularity in the atomic distribution.

The Libbey-Owens-Ford Glass Co., Toledo, has completed a new time-payment plan for residential modernization and commercial installation projects. It is known as the Libbey-Owens-Ford Modernization Budget Payment plan, and is designed to take advantage of the liberal provisions of the National Housing Act.

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The National Association of Coin-Operated Machine Manufacturers has revealed that its members are very good customers of the glass industry. It seems that some 450,000 bagatelle or marble games have been installed during the past two years and that 3,000,000 square feet of glass was required for their manufacture.

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CORNING BUILDS NEW PLANT

Corning Glass Works has announced that it will build immediately an entire plant for the manufacture of fibrous glass products, or "glass wool," as it is popularly called. The new factory will be located near the Company's Fall Brook plant in Corning, which is about a mile from the main works and office buildings. The building will have a frontage of 240 feet, and slightly more than 55,000 square feet of floor space, exclusive of a 36 x 48 foot boiler plant. Tanks will have a daily melting capacity of 24 tons.

Corning's decision to enter into the production of fibrous glass is significant of the importance attached to the future of this product. For two years the Corning Board of Directors has been studying its possibilities, and its recent action may be considered as indicating it may become a very large industry. Glass wool may be drawn so fine as to have a diameter of one twenty-five thousandths of an inch, and these gossamer threads may be spun into yarn and woven on looms. Electric cable insulation, fire-proof theatre curtains, cigarette-proof awnings are only suggestive of innumerable possibilities.

Construction of the new factory is to begin at once and it is understood the plant will be in actual production by Spring. The Simplex Engineering Co. is to build the unit from plans prepared by the Corning engineering department.

ROUTINE CONTROL OF WASTE FURNACE GASES

BY THE adoption of routine chemical analysis of the waste gases from the furnace the glass manufacturer can effect considerable savings in fuel consumption, and insure uniform and proper combustion conditions in his furnace, with the result that operating costs are lowered and production is increased.

The chemical analysis of waste furnace gases is an extremely simple procedure and is performed with a special instrument known as the Orsat Gas Analyzer. Several such instruments which are suitable for use in the factory are on the market and are so designed that the necessary manipulations are simple, fool-proof and may be performed by anyone who can read the instructions.

In brief, the method of analyzing waste gases by means of the Orsat is as follows: A known volume of the gas sample is passed first into a solution of potassium hydroxide and the carbon dioxide present removed. The volume of original gas thereby decreases and the difference between the original volume and the volume after absorption is the percentage of carbon dioxide. The residual gas is then passed into a solution of potassium hydroxide and pyrogallic acid and the oxygen present removed and determined in the same manner as the carbon dioxide. The gas remaining after this treatment is then passed into a solution of copper chloride and the carbon monoxide present determined. The residual gas is usually composed of nitrogen, but in some cases hydrogen and hydrocarbon gases may also be present. If these two gases are present, special methods and apparatus are necessary for their determination. This, however, is only necessary when accurate heat balance determinations are made. For ordinary work in the plant an Orsat capable of handling carbon dioxide, oxygen and carbon monoxide is all that is necessary.

The value of waste gas analysis will be better understood if the fundamental principles of combustion are first reviewed. The air that is used for supporting the combustion of the fuel is composed of approximately 21 per cent by volume of oxygen and 79 per cent by volume of nitrogen and other inert gases. When the air enters into reaction with the fuel the inert components of the air remain unchanged while the oxygen reacts with the oxidizable elements or compounds in the fuel to form gaseous oxides. This reaction may be perfect, complete or incomplete. Perfect combustion is the result of supplying the requisite amount of oxygen for combustion with all of the oxidizable constituents of the fuel, and utilizing in combination all of the oxygen so supplied. On the other hand, complete combustion results from the oxidation of all the oxidizable components of the fuel with an excess of oxygen being left unused. Incomplete combustion is the result of supplying insufficient oxygen to meet the needs of the fuel, with the result that part of the fuel is not oxidized and remains unburned.

When combustion is perfect, the waste gases are composed of carbon dioxide, water, nitrogen and sulphur compounds when the fuel contains carbon, hydrogen and sulphur. As it is rarely possible in practice to attain perfect combustion, complete combustion of the fuel is attempted. When combustion is complete, the presence of oxygen is also found in addition to the compounds formed in perfect combustion. When combustion is neither complete nor perfect, both oxygen and carbon monoxide are found in the waste gases.

With the exception of those special cases where the presence of carbon monoxide is desired in the furnace, complete combustion of the fuel is the aim as the presence of carbon monoxide (the sign of incomplete combustion) in the waste gases shows that unburned fuel is going out of the stack and represents a money loss. Complete combustion of the fuel is accomplished by the use of an excess of air over that required for perfect combustion. If too large an excess of air is used, large heat losses, due to the extra heat carried away by the increased volume of oxygen and nitrogen, will occur and will in many cases equal the heat loss due to incomplete combustion.

Waste gas analysis, therefore, may be used as a guide to several of the variables that are encountered when attempting to burn fuel in a furnace. Daily analysis of the waste gases from the furnace will quickly show changes in fuel quality, proper and improper combustion conditions, checker clogging, draft changes and air leakage. Air leakage, due to cracks in the checkers or recuperators, may be readily detected by taking samples of waste gas from different points and comparing their analysis.

While the method employed in analyzing waste gases is standard, there are several points that must be considered when securing samples: 1. The sample should be taken (routine tests) from a part of the furnace that is under positive pressure and as close to the end of the reaction as possible. This insures the collection of a sample that is representative of the actual conditions and is not contaminated by air leakage. 2. The sample should be taken from a portion of the furnace where the gases are traveling with a high velocity and considerable mixing is taking place. 3. Iron sampling tubes should not be used as carbon dioxide passing over a hot iron tube decomposes into carbon monoxide and oxygen. Porcelain quartz, or water cooled iron tubes are satisfactory. 4. Samples should be analyzed as soon as possible and should not be allowed to remain in a vessel containing water for long periods. 5. As the glass batch gives off appreciable amounts of carbon dioxide the per cent of oxygen in the waste gas should be taken as the index to conditions.

SOCIETY OF GLASS TECHNOLOGY

A general discussion of glass melting furnaces featured the November meeting of the Society of Glass Technology, England. Papers read were as follows: "The Control of Glass Melting Furnaces," by W. Maskill; "A Survey of Surface Temperatures of a Glass Tank Melting Furnace," by H. S. Y. Gill; "The Distribution of Heat Losses in a Tank Furnace System," by H. S. Y. Gill; "Producer Gas Plant in Glass Manufacture," by F. J. Hurlburt.

The London section held its annual dinner on December 4. Its November meeting was featured by a visit to the National Physical Laboratory, where members of the section saw much of interest, including various chemical tests of glassware.

MOVEMENTS OF GLASS MEN

U. E. Bowes, Director of Research of the Owens-Illinois Glass Company and chairman of the Glass Division of the American Ceramic Society, has moved from Alton, Illinois to Ohio. Previously he was at Clarion, Pa., with the Berney-Bond Glass Company; it appears that Dr. Preston has no photograph of Toledo from the air, but he provides us with Fig. 1, showing the Clarion Plant of the Owens-Illinois Glass Company (erstwhile Berney-Bond), and Fig. 2, showing the Alton Plant.

The Clarion Plant is right on the airline from New York to Cleveland, and "United's" Boeings pass over it all the time. This is in the region known as the graveyard of the aviators, on the first of the transcontinental air-mail routes. The Clarion River, in the background, has just come down from Cook Forest, only a few miles away, where the Glass Division held its summer meeting a couple of years ago.

The Alton Plant is on the Mississippi River, a few miles above its junction with the Missouri. The confluence is shown in Fig. 3. The camera is pointed west, and the right hand stream is the Mississippi. Alton, in this picture, is just off the right hand margin. The combined rivers flow down to St. Louis, just off the left hand side. A hundred years ago, Mr. Bowes tells us, St. Louis was described as being "near Alton" on the addresses of letters sent thither. In the middle distance can be seen the road connecting the two cities. On this road, a few years ago, Mr. Bowes was held up and robbed by bandits.

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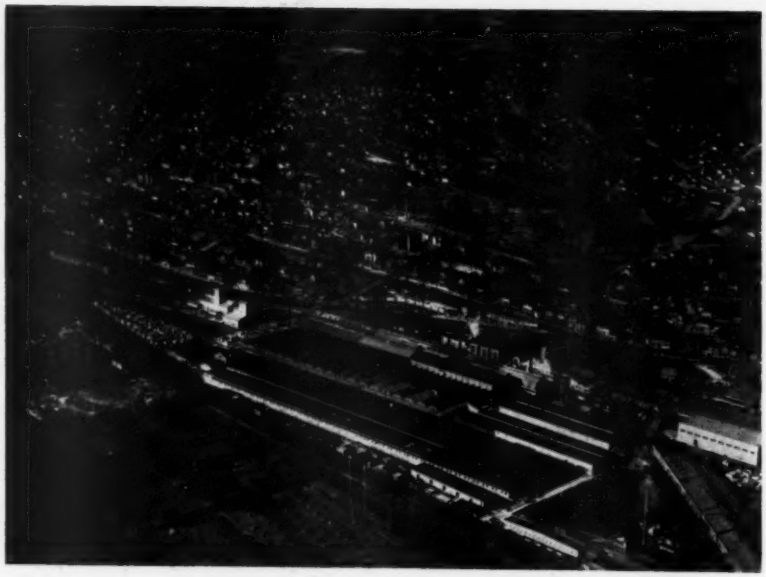

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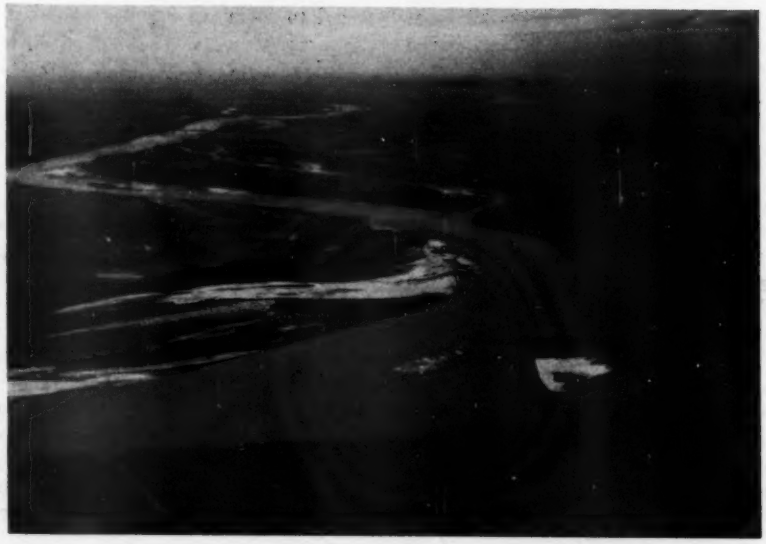

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The Inaugural Address of a Course on the

PHYSICAL CHEMISTRY OF GLASS at the University of Liege,

Given by Pierre Gilard

The issue of the 15th of November, 1935, of the Belgian journal *Verre et Silicates Industriels*, announces that the faculty of sciences of the University of Liege, Belgium, has created a chair at the University for the physical chemistry of glass. This chair has been entrusted to M. Pierre Gilard, Chief Engineer of the Cristalleries du Val-Saint-Lambert. This may mean that Belgium is at last following the example set by England in establishing a chair of glass technology at Sheffield, and America's establishment of a school of glass technology at Alfred. Belgium's stake in the glass industry is so large that a movement of this sort is very well warranted, and it is rather peculiar that it has been so long delayed.

Pages 414 to 419 of the same issue of the above-mentioned journal are devoted to the inaugural lecture of a course in the physical chemistry of glass at the University of Liege, given by Pierre Gilard. Believing that this is as simple and straightforward an account of the present status of glass technology as we commonly see, we have translated it into English, by permission, and herewith present it to our readers. The translator is F. W. Preston.

THE word "glass" is a generic term under which nowadays are ranged quite a series of materials possessing certain special properties. Among these are a number of substances, chemically homogeneous, formed of a single or of several constituents, such as selenium, boric oxide, silica, phosphoric acid; a number of organic substances such as brucin, salicin, grape sugar; also mixtures of two or more components, such as the waxes and lacs or lacquers; condensation and polymerization products, such as Bakelite and Durez; and finally, glasses with silica as their foundation.

All these materials have certain peculiar properties, a knowledge of which may serve to forward their use in industry, create new outlets, and consequently produce new sources of wealth, and, finally, to introduce logic into the industry and liberate us from the yoke of empiricism.

We do not believe that we can do better, at the start of our undertaking, than to make clear these points of view, and to illustrate by concrete instances the reasons which, on the initiative of the faculty of science of our University, have lead the government to establish a course in the physical chemistry of glass.

There is no industry that could serve this purpose better than the glass industry. Old as the world—for we find traces of it in the most ancient of civilizations—it has gone through all phases of evolution; from the most complete empiricism up to the present state where scientific knowledge dominates it completely, after having been for a very long time the province of the alchemist, first in the stages of the rule of thumb, and then with such prestige as was conferred upon it by a collection of secret recipes, jealously guarded.

The Industry takes hold of earthy products, and by the action of fire, draws forth from them a material, often of surpassing beauty, always of use, which has lent itself to the most diverse employment, which permits us to discover new worlds, infinitely large and infinitely small, or rather shall we say, which permits us to discover our world anew every day; a material which has taken, in the general structure of society, a place of the greatest importance, but which is nonetheless still very imperfectly understood, and in the ultimate analysis, still remains an undeciphered enigma; a material furthermore, which opens to science unknown horizons, and which by its very peculiar properties has been elevated to the rank of the prototype of a special state of matter to which, for this reason, has been given the name of the Glassy State.

A course in the physical chemistry of glass could not fundamentally be other than a vigorously pursued study of the glassy state, in the first instance by itself, and then in its relation to the other states of matter; finally, in its application, among which we shall encounter the important industries of glass and enamel making.

If, in a course of pure science, we are sometimes led to make incursions into the domain of applied science, you will easily understand the reason by recognizing that in our particular instance, if science has enabled industry to progress, the latter in its turn was the initiator of the researches, and the primary cause of the marvelous advance which has been made in recent years by the physical chemistry of glass.

On the face of things, the manufacture of glass is a simple enough matter; all that is necessary is to intro-

duce into a pot a suitable mixture of certain materials —sand, chalk, and soda, for example—and raise it to a high temperature in order to obtain the transparent limpid product which all of you know.

The mass, at the temperature of formation, is more or less fluid, and thickens constantly as it cools. When it has reached a suitable consistency, it can be gathered and worked. After cooling off completely it is as rigid as stone, and has all the appearance of a solid body.

The products obtained by melting will evidently vary with the materials used in the first instance, and with their degree of purity. And if we wish to produce a glass possessing certain definite properties, for example a beautifully white glass, it is necessary to eliminate from the batch elements capable of coloring it.

This relative ease of making glass explains in a great measure the antiquity of the industry, which as you know, goes back to the most ancient days. It explains also the degree of perfection attained by the men of old in its working, since in the ultimate analysis this perfection is based upon the skill of the operators, and every age has had its artists.

It explains moreover, the stagnation of the industry in the course of time; the greater part of the manufacturing processes, blown and rolled glass for instance, were known long before the Christian era, and up to the middle of the nineteenth century, men have generally been content to follow in the furrow traced before them. We do not deny that at all times efforts have been made to improve processes. A good deal of effort has been expended also in describing, often quite minutely, the stages of manufacture, and to comment upon the phenomena observed; it is only necessary to read the old works on the subject to see that glass was one of the preoccupations of certain alchemists, and the "secrets of manufacture" that the gentlemen glassmakers guarded so jealously are a proof that each of them was trying to discover something new and to do better than his neighbor.

We shall simply say that up to the middle of the nineteenth century the nature of glass scarcely occupied the attention of those who worked it. It was by empirical gropings that men attempted to overcome the various accidents that occurred, and by similar gropings that they arrived at methods of regulating and perfecting methods of manufacture. Chemistry and physics were in those days two completely distinct sciences, and the bonds which nowadays unite them so tightly were still unknown. In those days there did not exist as yet any science of glass.

THE fact that the glass industries walked so long in the beaten path should not astonish us very greatly. Nowadays when a science of glass has begun to become established, a great many glass manufacturers ignore it entirely and still retain their old-fashioned methods of operating.

If, on the face of things, matters are simple, in reality they are quite complex, and glass manufacturing is a difficult art; for glass, as I have already said, is an enigmatic substance, and the study of the glassy state is still in a rapid state of evolution. I will describe it very briefly.

All of the materials which we meet in nature may be divided into two great categories: crystalline substances and amorphous substances. There exists beween them a profound difference; in the former, the substance is perfectly organized[1]; in the second category, on the other hand, it is not. Crystals are molecular structures, perfectly arranged, they are anisotropic[2]—that is to say, their properties are not the same in different directions —and the passage from one state of aggregation to another—from the solid state to the liquid state, for example—always occurs in a discontinuous fashion[3].

Amorphous bodies, on the other hand, even in the smallest part, give no evidence of molecular arrangement; they are isotropic, that is to say, their properties are the same in all directions, and the passage from one state of aggregation to another is made without discontinuity.

Crystals are the prototype of the solid body, they are the normal state of solid matter; liquids and gases, whose molecules are endowed with movement, practically incompatible with molecular structure of any sort, are in the category of amorphous bodies.

As our knowledge of the physical state of matter increases, however, it shows more and more that it is not possible to formulate for a particular state, a very strict definition.

The crystalline state used to appear, above all others, capable of such a definition. All its properties seemed to indicate a rigid structure formed by the regular superposition of its ultimate particles. The discovery of liquid crystals necessitated an extension of the idea of the crystalline state, and has involved degrees in the structure of crystalline substances.

GLASS, as its properties indicate, falls in the category of amorphous substances. It is normally isotropic, and it passes by imperceptible stages without any discontinuity, from the apparently solid state in which we know it, to a pasty condition, and finally to a relatively fluid condition, as we raise its temperature. Inversely, it passes from the pasty condition to the rigid state without discontinuity when the temperature is lowered, without solidifying, in the physical sense of the word, since it does not possess a point of solidification; it simply acquires, in proportion to the lowering of temperature, a greater and greater viscosity, and finishes by acting like a true solid without it being possible to lay one's finger on the moment when it ceases to be liquid. The cooling process has not modified in any way the molecular state of the mass. All that has happened is that the early agitation of the molecules has been progressively reduced with the reduction of temperatures; they finish by being completely restricted in their movements, by being virtually immobilized, without becoming arranged in any regular manner.

There exists therefore, between the substance thus obtained in an apparently solid condition, which is not at heart anything more than a super-cooled liquid, and a crystalline medium, a profound difference which is sufficient to range glass and other substances which behave like it, along with gases and liquids, in the category of amorphous substances.

Furthermore, recent work has established the existence

of anomalies in the properties of glasses whose sum total shows that there are discontinuities between the isotropic amorphous state characteristic of low temperatures, and the pasty or fluid condition characteristic of high temperatures.

These discontinuities have been established for such properties as density, refractive index, thermal expansion, specific heat, and electrical resistance, and are produced in a relatively restricted range of temperature —called the critical interval—whose upper limit marks the passage to the pasty or plastic condition[4].

Below the interval where these anomalies are encountered, we should have a true amorphous solid state whose rigidity arises from a high degree of viscosity with virtual immobilization of the molecules, involving as a consequence, the mechanical properties of solids, the molecules being nonetheless arranged with respect to each other simply according to the law of probabilities, which would result in an isotropic ensemble.

Above the critical interval, the glass is plastic, and its viscosity varies rapidly with change of temperature. The state of the glass under these conditions has for this reason received the name of the viscous state. It persists up to the temperature called the aggregation temperature, which varies with the nature of the glass; thereafter we encounter the passage to the liquid state.

Glass therefore, seems to be a special substance, existing under three states of aggregation: the rigid state, the viscous state, and the liquid state. These characteristics seem to justify the particular classification which is the object of our study.

WE SHALL not today go into the question of the ultimate nature of glasses. It has been—so far as industrial glasses in particular are concerned—the object of numerous researches. No substance perhaps lends itself better to hypothetical interpretation, for the risks involved in its manufacture and the technique of its manipulation present the most varied circumstances, and the theories confront each other, each one attempting to throw some light on the mystery of the glass's ultimate constitution.

The generally accepted theory up to date, more particularly as concerns glasses with silica for their foundation, is that of a solution which may be either simple or colloidal, presenting in one way or another all the particular cases of aqueous solution, but no one is able even yet to indicate with precision the nature of the molecular combinations in the glassy state. This hypothesis is reasonably probable, but it does not simplify matters very much, for the dissolving of the component substance is produced at a very high temperature. The gradual cooling off results in an overcooled mass which is theoretically unstable and subject to crystallization, at any rate until a certain temperature is reached; this instability, from a practical point of view, has consequences of the greatest importance.

When, in the beginning of our discussion, we called attention to the apparent simplicity of methods of manufacture, we also indicated that in reality matters are not so simple as they might appear. Melting conditions are determined by the chemical composition of the batch, and the temperature of operation varies primarily therewith. And if fundamentally, glass is obtained by putting into a furnace in a suitable receptacle, the substances which go to make up this glass, and in heating the mass to the necessary temperature, it is nonetheless necessary to surround that operation with a great array of precautions, for glass melting is, at heart, an exceedingly complex matter; there is implied in the first instance a careful choice of constituents, and a very painstaking mixing thereof, because it is necessary to obtain a thoroughly homogeneous mass.

However, these constituent materials are of very different nature; some are stable, some are volatile, some are decomposed by heat at varying temperatures, and finally the rates of reaction and the mutual solubilities of the elements or of the products of reaction are very different, and it is essential by a preliminary intimate mixing and by a meticulous regulation of the firing cycle thereafter, to cause a reaction to take place at the appropriate moment, so as to avoid a precipitous flight of certain components, their separation in the form of a scum on the surface of the bath, or their settling down to the bottom of the pot or container.

Furthermore, the constituents are introduced in the form of powders into refractory containers which are capable of partially dissolving at the contact face, and thereby introducing into the bath undesirable elements, a phenomenon which is accentuated by the currents established in the containers under the influence of heat, and of differences in density of the mass at various stages of fusion.

The complexity of these matters, and the lack of precise knowledge of the melting process, have at all times had their influence on the results of the operation. It is only at the cost of long experience and innumerable gropings in the dark, and everlasting watchfulness, that we have succeeded up to date in marching in the path of progress. Up until very recent years, there was entirely lacking any scientific basis, and it would have been quite impossible to estimate in advance the consequences of a change in the usual method of operation.

Nowadays we are beginning to be a little better posted. A knowledge of the thermodynamics of the constituent oxides, a study of systems with two or more components, have proved capable of offering to glass makers very valuable suggestions on modifications that may be introduced into their glasses for the purpose of rendering them more or less fluid at a particular temperature, or upon the temperatures that should not be exceeded during the cooling process if they wish to avoid devitrification, and so forth.

A STUDY of the various systems is unfortunately extremely laborious, for, independently of the fact that the researches must be carried out at a high temperature, the possible cases are extremely numerous; we meet in the silicates practically all the various cases which aqueous solutions offer us. In the case of commercial glasses, furthermore, the number of components is usually great. Systems with three or four principal components are the rule and not the exception, and a study of their behavior is all the more difficult. It is still more so in the first instance, for the further reason that only a few systems up to date have been studied in a reasonably complete fashion. These studies have permitted us—for window and plate glass more particularly—to estimate the prac-

tical boundaries of the existence of the glassy state, to map out the compositions giving homogeneous glasses, and the limits of temperature between which they may properly be worked.

They have revealed also the composition of the crystalline phases which form under certain conditions, which give rise to the greatly feared phenomenon of devitrification stones in glass.

With the nature of a difficulty understood, one may proceed more readily to avoid it, and the advantage of scientific research is that it provides with but little delay a remedy for many accidents which long and costly blind experimenting could only clear up with difficulty.

From a practical point of view, it is still important to choose from among the possible mixes, those which are fusible at a normal temperature of furnace operation, so as not to prolong beyond measure the duration of the melting process, an indispensable condition for a high rate of production; but the melting process must not be too easy on the other hand, because this generally results in a glass composition of insufficient durability. Our difficulties do not end there, and a constant chemical control of the materials put into the furnace is essential, for the glassy substance is extremely sensitive to minor modifications. Differences of one or two per cent in silica, the principal component, or of one per cent in lime, or of one-half of one per cent in alkalis, in glasses of the soda-lime family, and a very small fraction of one per cent in the case of coloring matters can completely ruin the product.

Furthermore, while certain glasses are melted in closed pots, others are melted in open pots or in tanks. As some of them may be exceedingly sensitive to the reducing or oxidizing atmosphere of the furnace, it is necessary to check up on the latter and to adjust it to the composition being melted, in order to obtain the desired result. The scientific control of the furnace—gas analyses, and control of the temperatures and pressure in the furnace—are fundamental to a businesslike operation.

Melting is only the first step in obtaining glass. It gives a rough product, which has to be refined and clarified to form a limpid mass. This operation must be closely followed. According to certain writers, it does not consist solely of the physical process of eliminating gas bubbles set free by the fusion operation, but is a chemical process in the course of which the reactions are brought to completion. At elevated temperatures the ability of glass to dissolve gas is very pronounced. It decreases when the temperature diminishes[5]. Some glasses are capable of holding large amounts of gas in a supersaturated condition. Recent researches have shown even that in the completely rigid state, perfectly clear glass, perfectly homogeneous, may contain quantities of gas corresponding to several times the volume of the glass, a fact of capital importance from the point of view of the internal structure of the mass, for the usual presence of a gaseous phase in glass must have an influence which it is essential to know with some precision, in comparison with the properties of glass which have been rendered gas-free by a treatment in vacuum.

Glass is melted simply in order to be worked and elaborated in various objects. This phase of manufacture is, without the slightest doubt, from an industrial point of view, the most important.

Until very recent years the working of glass was essentially a matter of manual skill. Glass makers constituted a privileged caste where professional skill had created a complete hierarchy. They enjoyed a special consideration which had been conferred upon them by their talent in the face of difficulties which every day presented to them to conquer.

Nonetheless the working of glass had acquired a remarkable perfection.

Manual skill and craftsmanship are flexible tools which lend themselves to the overcoming of the most difficult problems, and permit results to be obtained which no machine is able to give. Several branches of glass manufacturing, the making of crystal and table ware particularly, in which the purest art must often be combined with industrial demand—have left to craftsmanship all its prestige. In other branches on the other hand, the machine has supplanted men, and a thoroughgoing mechanization of the equipment has permitted the desired results to be obtained.

In window glass making for example, the drawing machines are arranged along the working compartment of enormous tanks producing continuously sheets of glass of a quality which the older procedures could never have given.

In the hollow ware business, mighty machines, marvels of modern mechanism, fashion at a pace which leaves one dizzy, pieces of the most varied form, from lumps of glass which they automatically gather for themselves from the tank, or which they receive from the tank through the intervening feeders which supply them with a mathematical regularity.

Whatever may be the method of manufacture adopted, glass in order to be worked, must be carried to such a temperature that it possesses the desired viscosity which varies according to the character of the pieces to be fabricated and the working procedure adopted.

The viscosity of glass for drawing by the Fourcault process is not the same, for example, as that of glass for making thin sheets by the Libbey-Owens process, or for pressed tableware made on automatic machines. The fact must not be lost sight of that work is done upon glass in a viscous condition, which means, in an interval of temperature where viscosity varies very rapidly. It is this fact which complicates in a singular manner the working by hand of glassware which in the course of operation is cooling more or less rapidly, according to the shape of the piece, and which demands accordingly a succession of reheatings which greatly drags out the time of manufacture.

Again, the study of viscosity is of capital importance, above all, in automatic manufacture, wherein the glass fed to the machine ought to have continuously the same consistency. However, this property varies with the temperature and with the composition, and it is important to be very well informed about the possibilities of variation. For this reason, a good deal of attention has been given to the determination of viscosity, a difficult problem which up to the present time has not even yet received a final solution.

We may add also that certain mechanical methods of operating have required a knowledge of another prop-

erty, namely, surface tension. The results obtained to date on this subject are not very complete, and researches in this field should be pursued further.

The problem of raising glass to the correct working temperature and holding it there would not present nearly the same difficulty if one did not run across another danger in this region which it is of the greatest importance to avoid; this is the devitrification, or in other words, the partial crystallization of the mass. The rate of cooling here plays a role of vital consequence. Devitrification of the glass takes place in a variable interval of temperature depending upon the composition of the glass and the extent to which it is supersaturated with certain elements. Since all crystallization demands a certain molecular freedom, and in order to proceed, requires the maintenance of the medium at a favorable temperature, it is important, for the purpose of avoiding it, first to choose the composition judiciously, and then to go through the dangerous zone of temperatures with sufficient speed to carry the glass down to a temperature where crystallization is no longer possible. As we have already said, the study of ternery and higher systems may be of a certain help in avoiding this troublesome phenomenon.

The last operation in the manufacturing sequence, properly so-called, is the annealing process.

Its purpose is to eliminate from the manufactured articles those internal stresses which have arisen in the course of working and would undermine the stability of the ware if they were not caused to disappear. We have already mentioned that the viscosity of glass, in a certain range of temperature, varies very rapidly; in the neighborhood of the solidifying point, the coefficient of viscosity doubles in value for a drop of temperature of ten to eleven degrees Centigrade. It follows that, whatever may be the ware that one is interested in making, the parts in immediate contact with the surrounding atmosphere become solidified more rapidly than the interior of the mass which cools more slowly. Internal stresses of considerable amount thereupon place the whole in a state of unstable equilibrium, which is the more accentuated in proportion as the internal stresses are greater, that is to say, according as the pieces are thicker or their form more complicated.

A piece of ware in this condition is destined to break, and fracture, often of a violent character, takes place a few moments after it has been made. In order to avoid this, and to ensure permanent strength, it is necessary by an annealing process to reestablish molecular equilibrium throughout the mass. However, this annealing process must be carried out at a well defined temperature, which varies with every kind of glass, and must be sufficiently high to ensure the necessary freedom of the molecules, but sufficiently below the temperature of softening so that the pieces do not become deformed.

When equilibrium has been established, and the internal stresses eliminated, it is necessary by a careful cooling off process to bring the whole object down to room temperature without reintroducing new tensions, new stresses.

The annealing process is therefore an extremely delicate operation which must be controlled witth precision. It is carried out, in hollow ware at least, in special furnaces which are called ovens[6], whose temperature is regulated mathematically and controlled constantly by precision pyrometers. We have here traveled far from the primitive procedures, which consisted in burying the ware in the hot embers immediately after forming in order to prevent it from breaking. The theory of the annealing process is very complicated—we shall have occasion later on to explain it—but it has permitted us to obtain remarkable results, particularly in the case of optical glass, where the presence of strain would prohibit the use of even the most successful pieces.

The internal pressures in the glass are revealed by examination in polarized light, where they give rise to color patterns whose intensity and distribution indicate the character of the ware.

The polariscope, which gives us this information, is as necessary to the glass maker as the microscope is to the naturalist or bacteriologist—and science in this particular, as in many other phases of glass manufacturing, has laid its hand upon the rudder.

We might proceed to multiply instances without number, to talk about methods of coloring glass, either direct or by flashing, whereby one may obtain an almost infinite gamut of tints with precision and safety, procedures such as decorating by acid, by sand blasting, by vitrifiable colors, whose mechanism we have been able to establish and obtain thereby the maximum of results.

Furthermore, our increasing needs have called for the manufacture of special glasses—chemical ware, optical glass, fused silica, glass transmitting or opaque to ultraviolet or infra-red radiation, to X-rays, and so forth—which must possess well-determined properties; only scientific research has been sufficient in these matters to guide the glass maker towards meeting these requirements.

Scientific research alone can insure complete success, for it is necessary that the products obtained possess, in addition to those qualities on which one's attention is fixed, a mechanical strength and a permanence or durability without which no use is possible.

We shall not spend the time now on these points; later we shall have occasion to study them in detail.

This study moreover, makes its appeal to the emotions and imagination, independently of the practical results to which it may lead, for it brings us to grips with an enigmatic product whose properties are very imperfectly understood, a veritable Proteus whose transformations escape our grasp, a material fundamentally very ancient, which is revealed to us little by little and brings to science a new and unexpected contribution towards the understanding of matter.

The glass industry in Belgium represents no insignificant part of the national patrimony.

Our object in the present discussion has been to draw attention to the necessity of acquiring such knowledge as will enable this industry to make progress.

We shall only arrive at such knowledge by a vigorous investigation and study of the glassy state and of the physical-chemical laws upon which it is based.

It is towards this end that the course in the physics and chemistry of glass will be directed.

We hope in this fashion to fulfill the wishes of the faculty of science of the University of Liege whose fore-

(*Concluded on page* 27)

NEW TUNNEL TO HAVE GLASS ROOF

The practicality of using glass tiles for the ceilings of tunnels is emphasized by the acceptance of the Port of New York Authority of this material for the Midtown Hudson Tunnel, which is now under construction. 800,000 glass tiles, forming the largest glass ceiling in the world, have been purchased from the Macbeth-Evans Glass Co., Charleroi, Pa., for this purpose. Each piece is six inches square and is cream colored, stippled to eliminate glare and improve lighting. Installation of the material is expected to begin in February or March. The stippled glass was supplied at a cost of 86 cents a square foot, the total value of the contract being estimated at $160,000. Engineers on the projected tunnel anticipate large savings in cleaning and painting charges from the new material.

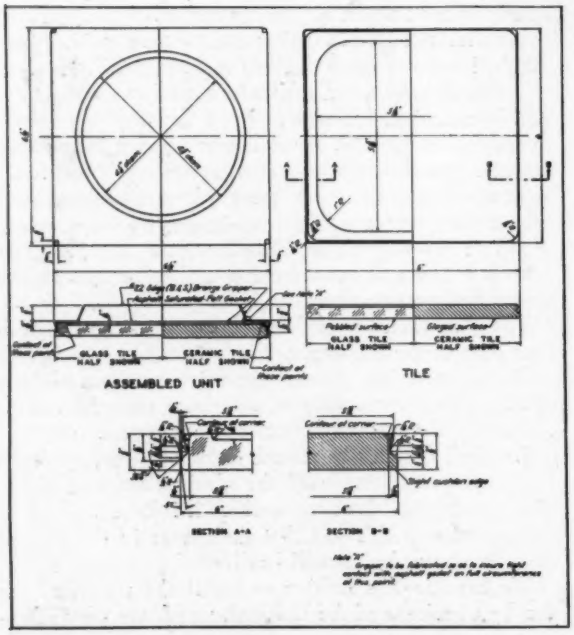
Ceilings have always caused civil engineers engaged in under-river tunnel construction considerable difficulty because of the combined moisture and vibration involved. In order to avoid shaking loose any tiles, the entire ceiling of the first Holland Tunnel connecting New York and New Jersey was made of concrete which was then painted. However, this involved a considerable cost in cleaning and painting which makes such a ceiling undesirable.

In order to make the use of glass tile ceilings practicable, some means had to be found to prevent them from falling out of the concrete. In addition to the vibration, seeping water swells the joints and thus pushes out the tiles.

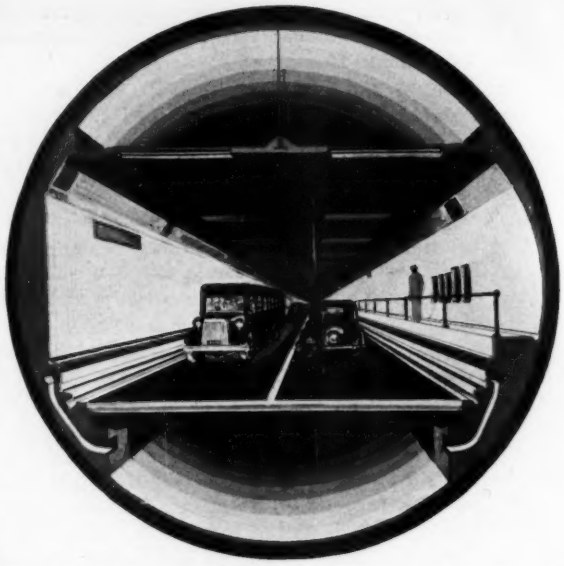
For years, H. P. C. Keuls worked on this problem. Finally with Charles G. Duffy, a way was invented to hold glass tiles and bricks in place so that they could not possibly loosen. They devised a gripper which is a non-corrosive metal frame that snaps over the edges of the tile, a bead in the frame fitting neatly into a groove in the tile.

As to the actual construction of the tunnel, masonite, an artificial wood, will be placed on steel forms. On this the tiles will be laid face down on gummed paper. The concrete will then be poured over the backs of the tiles, filling special recesses and flowing into joints. Thus the tiles and the concrete will constitute a single mass, the tiles being held together by the grippers.

Thus, glass has found another field of usefulness—as ceilings for tunnels.



How the problem of tunnel vibration was solved.



First drawing ever published of the new tunnel construction, showing glass ceiling installation.

E. L. Hettinger, Wilson Products Co., Reading, Pa., recently addressed the students and faculty of the Department of Ceramics, Pennsylvania State College, on the history of the heat treatment for strengthening glass. An interesting feature of his talk was a demonstration of a new type of polariscope which uses iodized quinine sulphate as the polarizing and analyzing material.

NEW USE FOR SAFETY GLASS

Glass manufacturers will be interested to hear that shatter-proof glass has been installed in the nursery of the Dionne quintuplets. It seems that the young ladies have grown so lusty on all the foods which they have endorsed that they are now given to throwing anything they can lay their hands on. So instead of ordering all windows boarded up, wise Dr. Dafoe has installed safety glass.

Air Hygiene Foundation of America, Inc., has been formed by a large group representing various industries, with headquarters in Pittsburgh. A comprehensive investigation has already been begun at the Mellon Institute of Industrial Research with the support of the Air Hygiene Foundation, to study the hygienic, technologic and economic aspects of air contamination.

The Department of the Interior estimates that it will take about three billion dollars worth of materials to meet the present housing shortage.

A REAL GLASS FACTORY IN MINIATURE

THE only authentic working model of a glass factory ever made has just been completed by the Bausch & Lomb Optical Company, Rochester, N. Y. This very remarkable toy, which cost $8,000 and required a year and a half to construct, was conceived by Theodore B. Drescher, vice president of the Company. Mr. Drescher had been impressed by the intense interest shown by visitors to the factory, of whom more than 2,000 pass through the plant every year. Accordingly he decided to have a working model built which would faithfully demonstrate each step in the manufacture of optical glass, and which he could dispatch on tour of the larger cities all over the country, display at scientific gatherings, industrial conventions, museums, and the like. The model is the work of Kenneth C. Burroughs and Donald Peterson, technicians of Bausch & Lomb, and Robert H. Barnes, Instructor in Mechanical Design at Edison Technical High School, Rochester.

The midget optical plant is equipped with a battery of three melting tanks, raw material bins, mixers, annealing ovens, casting tables and cutting rooms. Small electric trucks, manned by pigmy operators, transfer the molten glass from the furnaces to the casting table, where it is automatically rolled into sheets and conveyed into the annealers. Neon tubes, ingeniously placed, supply the realistic glow that gives the appearance of molten glass.

To synchronize the operation of the many moving parts, four major mechanical assemblies are required. The first of these takes care of the sand truck. When the truck reaches Furnace No. 1, a chute enters the furnace door and withdraws, and then the truck returns to the mixer for reloading.

Assembly No. 2 now comes into action and operates the pot truck. This assembly rotates a turn-table, opens and closes furnace doors, and tilts the pot at the proper time.

The casting table is an endless steel belt with an opening cut into it. A piece of glass and a neon tube provide the realistic touch of molten glass. This assembly is a complicated system of chains and sprockets which causes the roller to move down the table, and flatten out the glass.

Synchronized with the operations just described is an automatic film balopticon, which projects a story of each operation on the screen at the top of the model, shown in the accompanying illustration.

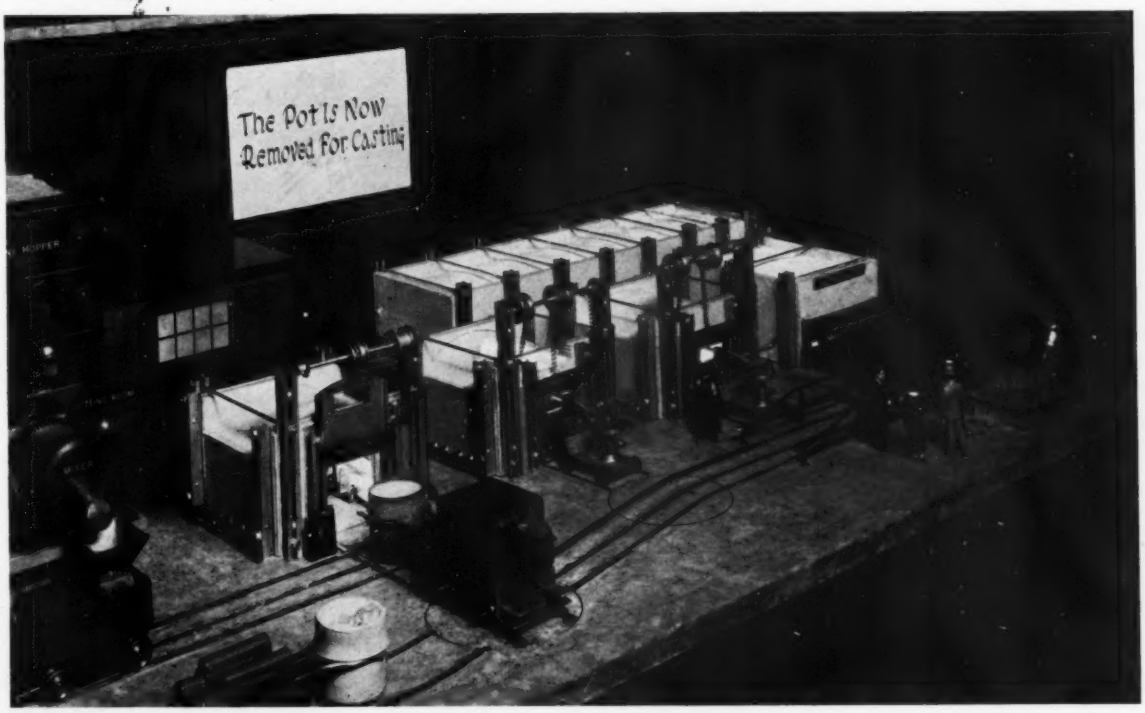
Five motors used in the model are controlled by fourteen electrical circuits, requiring fifteen switches and six relays.

NEW HERSHEY BUILDING WINDOWLESS

A three-story office building without windows is being constructed for the Hershey Chocolate Corporation in Hershey, Pa. It is claimed that this scientific production of artificial working conditions will be an improvement over the usual daylight conditions of changing light and weather conditions. Workers interested in what the weather is like outdoors, will be kept informed by an electric signalling system as to just what they may expect.

GLASS WOOL ROUTS WORMS

Onslaughts of the dreaded army worm in attacks on trees have definitely been stopped by the application of strips of glass wool to the trees. The "wool," which is manufactured by a secret process in which steam is used to convert glass into fibrous form, is used ordinarily for insulating buildings and houses, air filtering, acoustics and many other purposes.



Operating model shows how optical glass is made.

NEW BOOKS

Enamels. Andrew I. Andrews, Ph. D., professor of Ceramic Engineering, University of Illinois. Twin City Printing Co., Champaign, Ill. $5.50.

A comprehensive text on vitreous enamels including 64 tables which summarize valuable data on the many phases of enameling. Starting with a history of enameling, Dr. Andrews discusses in successive chapters such fundamental considerations as the physical properties of enamel glasses with the preparation of surfaces as well as the milling, application and firing problems. His concluding chapter deals with tests for various enamel properties.

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Refractory Blocks for Glass Tank Furnaces. By J. H. Partridge. Published by The Society of Glass Technology, Darnall Road, Sheffield, 1935.

English-speaking glass technologists are still awaiting the publication in English of a satisfactory book on glass technology. At present, nothing of the kind seems to be in sight, but at intervals there are published monographs dealing with limited fields of interest to glass technologists, from which we may by degrees be able to build up a library of glass technology in a satisfactory fashion.

The latest addition to this list of small books on special phases of glass technology is the above memoir by Dr. Partridge. Most of the material in this book has previously appeared in scientific papers, but in its present assembled form, the material is a great deal more valuable. In addition, it is arranged in an attractive and intelligent order so that a fair grasp of the entire subject may be obtained by one whose knowledge of the subject is at the outset somewhat limited.

Our fundamental knowledge of the physical properties of tank blocks, of clay substances, and of the mechanism of tank block corrosion in practice is still so limited that an adequate textbook on the subject will probably not be available for many years to come, but the summary by Dr. Partridge of our existing knowledge on the subject is an exceedingly valuable one. In this respect, the usefulness of the book is considerably increased by the presence of an excellent bibliography of references to scientific papers.

The book deals, in twelve chapters, with the raw materials at present in common use for tank blocks, the methods of preparing them, and of preparing the blocks from them, and the behavior of tank blocks under commercial conditions and under conditions of laboratory testing. We may perhaps add that, while the methods of making the tank blocks are described, no time is wasted in describing specific machines for the purpose. The book is written throughout very largely from the point of view of the user of tank blocks rather than the manufacturer thereof, except insofar as in some countries and in some plants, refractory shapes are made up by the user.

To a very great extent, the problem of making satisfactory glass is a problem of making a satisfactory vessel to hold the glass while it is being made, and therefore the problem of tank blocks, their limitations, and peculiarities is a matter of fundamental importance to every glass manufacturer. It would seem fair to say also, that at the present time our knowledge of glass and its physical properties considerably exceeds our understanding of the behavior of refractory substances. Therefore the present monograph is a very welcome addition to the literature of glass technology.—F. W. P.

●

Industrial Medicine. W. Irving Clark, A. B., and Philip Drinker, S. B., Ch. E. Edited by Morris Fishbein. Published by National Medical Co., New York. $3.00.

This little volume combines within a relatively small space the fundamentals of medicine as applied to industry and the scientific details given are within the grasp of the lay mind. Industrial disease and the multiplicity of hazards growing out of this problem are covered with just enough minutiae to intrigue interest in the several topics. The greater part of the material centers about the problem of silicosis. The action of sericite is also covered and the importance of lead is dwelt upon in an impressive manner.

●

"*America's Glass, First and Last*" is the title of an article by Carl Greenleaf Beede in *The Christian Science Monitor,* Nov. 9. Mr. Beede's article was inspired by an exhibition of American glassware at Harvard's Fogg Museum of Art which featured the glass of 1780-1820 as well as products of the present day. The writer appears to prefer the older craftsmanship and says, "Often, however, these modern products are either frank adaptations of classic forms or apparently strained efforts at novelty that leave the observer as cold as the ice they resemble, for there is no color in any of these modern pieces. Save for skilful engraving, which itself is nearly all traditional in character, they carry none whatever of that intimate expression of our fellowmen that so strongly enrich for us the earlier handiwork."

●

"*The Glass Industry: Its Expansion and Present Status*" is the title of an excellent analytical review published by The New York Trust Company in its monthly publication, "The Index", for October. Following a brief historical sketch, the article traces the development of glassmaking in the United States and analyzes production, operations and trends in the more important branches of the industry. The work is well done and should be helpful to investors, for whom The Index is published. Warren T. Walker, general sales manager of the Kimball Glass Company, Vineland, N. J., died last month at White Sulphur Springs, W. Va. Mr. Walker was attending the convention of the National Wholesale Druggists Association.

●

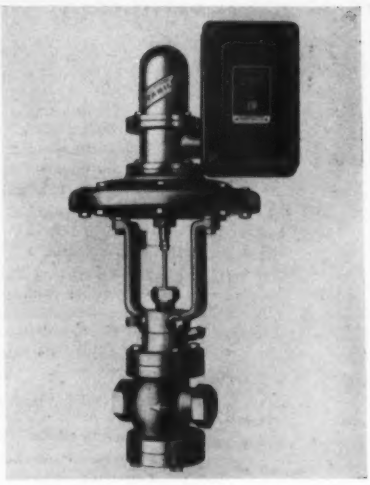
The publication of the "Minerals Yearbook, 1935," is announced by the Bureau of Mines, Department of the Interior. Containing 75 chapters, 129 illustrations, and nearly 1,300 pages, it constitutes a condensed library of current developments in the mineral industries. It chronicles the production of a hundred commercial minerals in the United States and abroad during the year 1934. Technical progress in the production of these minerals and their present economic position are reviewed.

EQUIPMENT AND SUPPLIES

ELIMINATES VALVE STICKING

A new accessory for air-operated control valves, the Vernier Valvactor, developed to eliminate valve sticking and to assure hair-line positioning is the latest addition to the line of control instruments manufactured and sold by The Foxboro Company. This device enables throttling type air-operated control instruments to make small gradual adjustments of the control valve position regardless of friction or hysteresis. It is claimed that the air from the control instrument need change as little as ½ inch of water to cause a corrective positioning of the valve and force the stem to take a position within 1/1000th inch of the previous one.

The Vernier Valvactor guarantees exact valve response where the valve stem packing must be very tight to prevent leakage; where the fluids are viscous or contain solids; and friction is otherwise unavoidable or wherever there is danger of valve friction developing. In the great majority of installations Foxboro control valves will respond proportionately to small change in air pressure without this device. This is especially true of Stabilflo valves. The Vernier Valvactor gives an added assurance that the valve positively will not lock itself in one position, and should be used wherever this assurance is necessary.



Stabilflo valve with Vernier Valvactor.

The unit is mounted in a cast aluminum case, is completely weatherproof, and may be exposed to the elements. The case is also available in gas-tight construction. It can be attached directly to the spring housing of all sizes of Stabilflo valves. For needle valves and valves without the Stabilflo type of motor, the Vernier Valvactor is mounted on the side of the motor supports.

The Foxboro Company, Foxboro, Mass., will gladly send additional information to any interested person.

PAINT IN STICK FORM

Helmer & Staley, Chicago, announce a unique product—real paint in crayon form. It can be used to write on any kind of surface, hot, cold, wet or dry—and the marking will remain permanently clear-cut and legible, even though exposed to weather. Uses suggested are for marking (1) parts, to facilitate assembly in production, (2) sections shipped knocked-down, (3) warehouse stocks, (4) for identification, to protect from theft, (5) addressing parts or packages of any kind. Helmer & Staley are located at 2524 South Parkway.

The United Feldspar Corporation announces that Robert E. Sherwood has become associated with the company as sales executive and consultant, with offices at 10 East 40th Street, New York.

APPOINTS PHILADELPHIA AGENT

General Refractories Company announces the appointment of The Bird-Archer Company, Philadelphia, as dealer agents in the Philadelphia area. The Bird-Archer Company will carry a complete stock of refractories.

Link-Belt Company, Philadelphia, has announced a new line of Cut-Tooth, Worm Gear Speed Reducers. These new reducers are available in a wide range of ratios and capacities, with single or double reduction, and in horizontal and vertical types. A 40-page descriptive catalog (No. 1524) sent on request.

CATALOGS RECEIVED

Steam Turbines for Mechanical Drive. GEA-1145C. General Electric Co., Schenectady, N. Y. A 16-page booklet, amply illustrated and diagrammed, discussing the application of this equipment to the plant set-up.

Research Puts the Diatom to Work. Catalog FA-7A. Johns-Manville, 22 East 40th St., New York. The history, development and industrial uses of a tiny plant, the diatom, from which Celite is made. Also given are the four principal uses of Celite: for high temperature insulation, filter aid, mineral filler and workability agent in concrete.

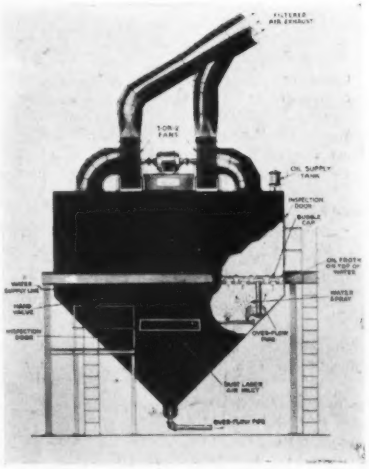
Air Operated Controllers, Bulletin 8900. Brown Instrument Company, Philadelphia. Describing a new line of instruments recently introduced for the precise measurement and control of temperatures, pressures, flows and liquid levels. Obtainable on request.

Electrical Measuring Instruments, "Broadside E." Leeds & Northrup Company, Philadelphia. Cataloging and describing (with prices) the full line of L & N instruments.

Royal Berlin Porcelain Ware. Fish-Schurman Corporation, New York, U. S. Agents. Describing the well-known line of laboratory and industrial porcelain manufactured by the Royal Berlin Porcelain Works, Berlin, Germany, which is used extensively in the glass industry in various shapes, such as pyrometer tubes, stirring rods, crucibles, etc.

Materials Handling Equipment Parts. Catalog 417. Jeffrey Manufacturing Co., Columbus. A 400-page catalog of conveyor chains, sprockets, transmission machinery and materials handling equipment of all types manufactured by this company. Illustrated, and contains specifications and prices.

Bartlett-Snow "Froth-Flotation" Air Filters. The C. O. Bartlett & Snow Co., Cleveland. A folder describing this equipment, the operation of which makes use of the principle that an air stream in passing through a blanket of low surface tension material is shorn of its dust loading. Standard sizes range from 1,000 to 35,000 cu. ft. per minute. This air filter is illustrated on this page.



The "Froth-Flotation" air filter.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.	...	1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.	...	5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	13.50	...
Tartaric	lb.	... Po. or Gr. .25 / Cry. .25½	
Aluminum hydrate (A1 $(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14½
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¾
Antimonate of Sodium	lb.	...	.13¾-.14½
Antimony oxide (Sb_2O_3)	lb.	...	.15¾
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	1.00-1.10
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.39
In 10 lb. tins	lb.	...	1.49
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	...	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08½	.09
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	31.50	...
In bags	ton	33.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black ($Fe3O_4$)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-23.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.07	...
In 5 Ton lots	lb.	...	.075
Less than 5 Tons	lb.	...	.08
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75	...
Litharge (PbO) (New York Prices)	lb.	.06	...
In 5 Ton lots	lb.	...	.065
Less than 5 Tons	lb.	...	.07
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide In Paper bags	ton	50.00	52.50-55.00
In Burlap bags	ton	51.50	54.00-56.50
In Casks	ton	53.00	55.50-58.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.09
Powdered	lb.	...	.09½
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07¾
Hydrated 80-85%	lb.	.06	.06¼-.06¾
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.20
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.30
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	... Po. or Gr. .13½ / Cry.	
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.)	per oz.	...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.07
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08¾
Sodium fluosilicate (Na_2SiF_6)	lb.	.05¼	.05¼
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) . in bbls.	lb.	...	.37
Tin oxide (SnO_2) in bbls.	lb.	...	.54
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.60
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.05	.05¼
White Seal, 150 lb. bbls.	lb.	.06¾	.07
Green Seal bags	lb.	.06	.06¼
Red Seal, bags	lb.	.05½	.05¾
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.05

PHYSICAL CHEMISTRY OF GLASS

(*Continued from page* 21)

sight in requesting the government to create this Course has placed within reach of those who so wish an opportunity to acquire an up-to-date knowledge of the glassy state, which in its totality, for various reasons, has not up to the present been the object of a coordinated system of teaching.

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[1]"Organized" in this sense means arranged in a recognizable and uniform pattern, as soldiers are arranged in ranks and files, or apple trees in an orchard, as distinct from the "disorganized" arrangement of a crowd round a soap-box orator or oak trees in a natural forest. F. W. P.

[2]This extraordinary statement is translated exactly as it stands, together with the following phrase in parenthesis. So many crystals are *not* anisothropic, and their gross properties are *not* different in different directions, that the statement is absurd as it stands, but in the French version there is no modifying or qualifying phrase. F. W. P.

[3]This is probably true, but perhaps more in theory than in practice, for crystals like cristobalite and crystal feldspar when they pass into vitreous silica or vitreous feldspar (if we may so term it) are so viscous that the transition is not the clear cut and "discontinuous" one that we find on melting tin or iron, for example. F. W. P.

[4]The present translator (F. W. P.), as is generally known, still fails to be impressed by these alleged discontinuities. They are not *discontinuities* in the curves connecting any particular property with temperature, but *changes in the rate* at which these properties change with temperature. They do not have the form of *changes of state*, but the form of slow *changes of a property* of a material in a single state. Littleton and Morey and others have indicated that these miscalled "discontinuities" can be interpreted as a freezing in of high-temperature properties due to increasing viscosity, as the temperature is lowered beyond the point at which equilibrium is reached promptly. And that is probably all there is to it.

[5]This statement is singularly unconvincing. Gases are usually more soluble in cold liquids than in hot, which is why we boil water to drive off dissolved air, H_2S, ammonia, and so forth; or boil mercury to drive off air when making a barometer. I am not aware that anyone has established that the reverse is true of molten silicates. F. W. P.

[6]The French word is "arches".

NOVEMBER PLATE GLASS PRODUCTION

The production of polished plate glass by members of the Plate Glass Manufacturers of America in November was 15,909,262 square feet as compared to 16,592,803 square feet produced in October.

SAFETY GLASS STANDARDS SUBMITTED

Specifications and Methods of Test for Safety Glass, a new safety code developed under the auspices of the American Standards Association, has been submitted by the sponsors for the Association's approval. The code, which is in two sections, is designed to be used by manufacturers of safety glass to determine the strength and other safety characteristics of glass. The first section deals with safety glass for automotive use and covers all the glass that might be conceivably used for this purpose.

A report from Chicago states that the building trades are expecting department stores will handle complete air-conditioning equipment for homes within the next five years.

GLASS BLOCK SALES BOOM

The unusual interest glass blocks have created in the building industry since they were introduced in their improved form three months ago, has resulted in sales that exceed those of the three-year period prior to that time, according to the Owens-Illinois Glass Co. It is pointed out that glass blocks are not a luxury, as the uninformed might think; in fact, they are said to be lower in cost than any other good quality construction material. Because of this fact, together with such advantages as light transmission and diffusion, insulation and fire resistance, glass blocks are destined to become a universally accepted material for use in general construction, builders and architects concede.

NOT SPOILED BY SOLARIZATION

Editor, The GLASS INDUSTRY:

We desire to call your attention to the next to the last paragraph in the first column on page 379 of your December issue of GLASS INDUSTRY in the article entitled "Glass in Modern Housing" by Mr. John Ely Burchard.

It is not correct that the real ultraviolet glasses such as Vita glass are spoiled by solarization. In fact, the transmission of Vita glass is guaranteed as follows:

"To purchasers of Clear Sheet Vita glass (approx. 21 oz.); 1/8″ Cathedral Vita; 5/32″ Plate Vita and Agricultural Vita glass—We agree that any Vita Glass supplied you by or through us (regardless of the time the glass is in window use), may at any time be tested by the United States Bureau of Standards, or at the Massachusetts Institute of Technology, and, if as a result of such official test it should ever be found that its transmission does not exceed the minimum standard of effective transmission which has been determined and published by the American Medical Association's Council on Physical Therapy, we will refund the cost of the glass and the test."

The minimum requirement of the American Medical Association is a transmission of 30 per cent at the ray 302 m.u. and the final permanent transmission of sheet Vita glass after solarization is roughly 40 per cent.

Solarization is a chemical reaction which takes place in the glass during the first two or three weeks of exposure to natural light. The iron in the glass becomes oxidized and when such little iron, as is there, is oxidized, the drop in transmission cannot go any further. This process as stated practically all takes place in the first two or three weeks of exposure to light.

We would be very glad if you would print this letter in your next issue to correct the statement referred to.

Vitaglass Corporation, P. H. Jennings, *President.*

Sales representative with sales force, well located office, show room and warehouse would like to hear from manufacturers of glassware and crockery who want representation in this territory. Best references as to responsibility furnished. Address C. R. Goold & Company, 2219 Cottage Grove Avenue, Chicago, Illinois.

FOR SALE: 3 glass combination machines for polishing, grinding and beveling. Also 6 cases flashed opal glass in colors. Globe Lighting Fixture Mfg. Co., 397 Seventh Ave., Brooklyn, N. Y. Telephone: SOuth 8-6782.

Special Machinery for Glass Plants

Built To Order

KENT OWENS TOLEDO OHIO

Quotations promptly furnished on receipt of blue prints

KENT-OWENS MACHINE CO.

958 WALL STREET - - TOLEDO, OHIO

DENSE
DUSTLESS
GRANULAR

GLASSMAKERS' ARSENIC

99% As_2O_3

This Arsenic was developed for the glass trade by the producer, the American Smelting & Refining Co., with the collaboration of our technologists. It was placed on the market in 1932 and since that time we have sold it to more than 60 glass manufacturers. Every glass manufacturer we have since interviewed has been more than pleased with this product.

We regard this as the most desirable grade of Arsenic for use in the manufacture of glass. Carlot shipments are made direct from the refinery and less carlot stocks are carried at Washington, Pa., Chicago, Ill., and New York, N. Y.

Produced by
AMERICAN SMELTING & REFINING CO.

Sales Agents
B. F. DRAKENFELD & CO., Inc.
47 PARK PLACE, NEW YORK

Branches: E. Liverpool, Ohio; Chicago, Ill.; Washington, Pa.

• WE MAKE...
• WE SELL...
• WE USE OUR OWN-

GLASS HOUSE REFRACTORIES

FLUX BLOCKS
POTS OPEN AND COVERED
REFRACTORY BLOCKS
HIGHLANDS POT CLAYS
PREPARED MIXES
SPECIAL BATCHES

P. B. SILLIMANITE

PITTSBURGH
PLATE GLASS COMPANY
Refractories Division
GRANT BUILDING • PITTSBURGH, PA.

Good Books
for the Glassman

In answer to many requests for books relating to glass and its manufacture THE GLASS INDUSTRY presents the following selection of interesting and informative works:

Defects in Glass By C. J. Peddle	$6.00
Electrical Properties of Glass By J. T. Littleton and G. Morey	3.00
Ceramics (a handbook) By A. Malinovszky	3.00
Ceramic Tests and Calculations By Prof. A. I. Andrews	2.25
Industrial Furnaces (Vol. 1)	6.00
Industrial Furnaces (Vol. 2) By W. Trinks	5.50
Modern Glass Practice By Dr. Samuel R. Scholes	6.00
Industrial Stoichiometry By W. K. Lewis and A. H. Radasch	2.50
Non-Metallic Minerals By R. B. Ladoo	6.00
Refractories By F. H. Norton	6.00
Silica and Silicates By J. A. Audley	6.00
Constitution of Glass By Prof. W. E. S. Turner	2.10

Send remittance with your order, or, if you prefer, instructions that we forward C.O.D. Prices quoted on foreign books are subject to exchange fluctuations.

The Glass Industry
Woolworth Bldg. New York City

ANNOUNCING

THE SIMPLEX INTERLOCKING SUSPENDED ARCH

Through extensive research and engineering skill Simplex has won wide recognition for leadership in the development of equipment for the glass manufacturing industry.

The new Simplex Interlocking Suspended Arch typifies this Simplex policy of pioneering . . . unique design and construction precludes the possibility of the arch falling into the metal or product in Glass Tanks or Steel Furnaces.

Before you specify—investigate the advantages of this new tank equipment.

SIMPLEX
ENGINEERING COMPANY

WASHINGTON TRUST BLDG. • WASHINGTON, PENN., U.S.A.

Glass Melting Tanks and Furnaces for every type of glass manufactured • Glass Bending Ovens, Glass Decorating Machines • Luminous Ports that give excellent control • Lehrs—Electric or Fuel Heated for Annealing or Decorating • Arches—Interlocking Suspended and Circular • Batch Systems—Vacuum and Conveyor Types • Fuel Oil Systems and Control, Stokers • Cullet Washing Plants, Incinerators • Conveying Equipment—All Types • Water Softening Plants, Silicate of Soda Plants • Producer Gas Plants and Soot Disposal Systems • Air Conditioning Systems •

PAGE(S) M

MISSING